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Low Mileage Catalyst Evaluation with a Methanol-Fueled Rabbit - Second Interim Report

(U.S.) Environmental Protection Agency
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Technical Report

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by

Robert D. Wagner
Larry C. Landman

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NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

U. S. Environmental Protection Agency
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Office of Mobile Sources
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16. ABSTRACT

This report summarizes a test program which was designed to evaluate various exhaust catalysts at low mileage on a pure methanol-fueled Volkswagon Rabbit automobile. Hydrocarbons, carbon monoxide, nitrogen oxides and formaldehyde emissions were measured to identify which catalysts are the best candidates for durability testing in a later program. Catalysts formulations that are eventually selected for durability testing should cost no more, and preferably less, than the orginal catalyst on the vehicle. In addition, all catalysts should provide the capability to meet the Federal Exhaust Emission Standards for hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NOx).

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Air Pollution Control Equipment		Concentration (Composition)	
Catalysts	Performance Evaluation	Catalytic Reactors	
Carbon Monoxide		(Exhaust Systems)	
Exhaust Emissions			
Hydrocarbons			
Methyl Alcohol			

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Background

The use of pure methanol as an automotive fuel could allow the use of less expensive exhaust catalysts. Two important benefits are expected from the use of methanol compared to unleaded gasoline. The benefits are reduced levels of catalyst poisons, such as lead and sulfur, and reduced exhaust gas temperatures at the catalyst inlet. Both major mechanisms of catalyst deactivation, poisoning and thermal degradation, could be less of a problem with methanol.

The purpose of this program is to evaluate various exhaust catalysts at low mileage on a pure methanol-fueled Volkswagen Rabbit. HC, CO, NOx, formaldehyde, and methanol exhaust emissions are measured. Two catalyst formulations have been identified for durability testing, and durability mileage accumulation has begun using those two formulations. Other formulations may be identified for durability evaluation. Catalyst formulations that are selected for durability testing should cost no more, and preferably less, than the original catalyst on the vehicle.

All candidate catalysts should provide the capability to meet the 0.41 HC and 3.4 CO levels at low mileage with substantial margins of safety. Additionally, 3-way catalysts should provide emissions well below the 1.0 NOx level.

Two catalysts have been tested in this project since the previous report was published. Data from all previously tested catalysts are also included in this report.

mesh which had been dipped in muriatic acid. The acid dipped copper catalyst did provide better control of HC and CO than the copper mesh catalyst, but it provided poorer aldehyde control.

7. Two catalysts have been tested which include both base and noble metals. The identity of the base metals are not known by EPA. The noble metal is palladium. The first combination of metals provided no significant emissions benefit in comparison to catalyst with no base metals that use of similar amounts of palladium in this study. The second combination of metals appears more promising, pending evaluation of the aldehyde data. The noble metal loading of the second catalyst is very low.

8. Several catalysts have been identified as good candidates for vehicle durability testing. All of these catalysts contain noble metals. Two catalysts have been started on durability mileage accumulation. They are 1) platinum and palladium in a ratio of 3:2 at 20 grams/cubic foot total noble metal loading, and 2) all palladium at a loading of 20 grams/cubic foot. Both monolithic catalyst substrates are 400 cells per square inch with a wall thickness of 6 mils.

Future Effort

The results which have been obtained so far will be provided to the vehicle and catalyst manufacturers who have assisted us in this program. We will request their advice on the following subjects:

- how to improve the emissions control capability of previously tested and poorly performing catalysts,
- which additional catalysts should be tested at low mileage,
- how to further reduce the cost of durability-candidate catalysts, and
- how to improve the durability emissions performance of those catalysts which performed well in our low mileage testing.

We plan to evaluate the following catalysts at low mileage as the program continues:

- Copper oxide
- Rhodium (with a loading of 5 g/ft^3)
- Palladium/Rhodium (with a loading of 10 g/ft^3 and a ratio of Pd:Rh of 5:1)
- Cerium (Ce) only

Based on our testing through April 20, 1984, it appears as though we may need to retain some rhodium for achieving the lowest possible aldehyde levels. As such, new catalyst candidates will also include platinum/rhodium and palladium/rhodium catalysts in the 5-10 gram/cubic foot range, with even less rhodium content.

Conclusions

1. Typical 3-way catalysts, like those now used with gasoline-fueled vehicles, contain platinum with rhodium. Both platinum and rhodium are noble metals. These catalysts worked very well on the methanol-fueled Rabbit as 3-way catalysts and as oxidizing catalysts.

2. Noble metal catalysts which contain platinum with palladium are typical of oxidizing catalysts that are currently being used for gasoline-fueled vehicles. This type of catalyst functioned very well on methanol as an oxidizing catalyst and also as a 3-way catalyst.

3. Catalysts which contain only palladium have also functioned well as 3-way and oxidizing catalysts. NOx conversion at stoichiometry was surprisingly high.

4. With noble metal catalysts, CO is generally reduced as the exhaust oxygen goes from stoichiometric levels to 3 or 5%. NOx converstion is lost with the same changes in oxygen level.

5. Catalysts which contain rhodium have been very effective for formaldehyde control at all exhaust oxygen levels. With other noble metal catalysts, conversion efficiency for formaldehyde is reduced as exhaust oxygen increases.

6. Two all base metal catalysts were tested. They were both pure copper mesh. The first copper mesh provided some HC conversion over the highway cycle, but not much else. CO control over the FTP was poor with the first catalyst, and it provided little NOx control with stoichiometric exhaust conditions. The second catalyst was an identical copper

Test Vehicle Description

The test vehicle is a 1981 model year Volkswagen Rabbit. It was modified by Volkswagen to operate on methanol plus 5.5% isopentane. It is a 4-door sedan equipped with air conditioning, a 3-speed automatic transmission, and a 1.6 liter engine. The compression ratio of the engine is 12.5:1. Maximum power output is about 88 horsepower at 5600 RPM [1]*. The tire size is 155 SR 13. The tires are Michelin XZX radials. It was tested at 2250 pounds inertia weight and 7.3 actual dynamometer horsepower.

The emission control system, as equipped by Volkswagen, includes feedback controlled, continuous fuel injection (K-Jetronic) and a three-way catalyst. The catalyst provided by VW was 4.0 inches in diameter and 6.0 inches long. It contained platinum (Pt) and rhodium (Rh) in a ratio of 5:1 at a loading of 40 g/ft^3. The vehicle is described in more detail in Appendix 1, which was taken from a Volkswagen emission control status report [2] to EPA.

The emission control system was modified by EPA to include a pump-type air injection system. The air was injected into the exhaust at a location about a foot downstream from the oxygen sensor. A manually adjustable valve was installed in the line between the diverter valve and the exhaust inlet. This valve allowed us to vary oxygen concentration into the catalyst while operating the engine in the closed loop mode.

Testing of catalysts on a second vehicle, a methanol-fueled Toyota Cressida, was begun in January 1984 as part of a program to evaluate catalyst durability. This durability program is being conducted in cooperation with the California Energy Commission, Ford Motor Company, and Toyota Motor Company. Durability catalysts were tested at EPA at zero miles on a methanol-fueled Toyota. The catalysts have been shipped to California where they will be run for about 10,000 miles on methanol-fueled Escorts. After mileage is accumulated, the catalysts will be shipped back to EPA for additional testing on the Toyota. The initial low mileage data generated in that program are included in Appendix 8.

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*Numbers in brackets are references listed at the end of this report.

Test Sequence, Instrumentation, and Fuel

The initial plan included testing of the vehicle and each catalyst over the following sequence:

1975 Federal Test Procedure
Highway Test Procedure
20 mph steady state
30 mph steady state
40 mph steady state.

The sequence was repeated twice for each catalyst at each of three exhaust oxygen levels. The higher two of the three exhaust oxygen levels were measured at the catalyst inlet using a Sun oxygen analyzer and were obtained at 30 miles per hour steady state. The three oxygen levels were stoichiometry (or near 0%), 3%, and 5%. The air pump was used to provide the 3% and 5% oxygen levels. By testing at different exhaust oxygen levels, we could evaluate each catalyst as a 3-way catalyst and also as an oxidation catalyst.

As the project proceeded, idle and a 10 mph steady state test points were added to the sequence and the 40 mph steady state test point was deleted. Idle was later deleted. HC, CO, NOx, MPG, methanol, methane, and aldehydes were initially measured over each test in the sequence. Measurement for aldehydes was deleted during steady states in the more recent testing. Measurement for methanol was deleted for all testing as the program progressed.

Exhaust HC emissions, as reported here, were measured with a flame ionization detector (FID) from Beckman (model 400). No corrections in the results were made for either the FID response to methanol or the difference in HC composition with methanol as the fuel. NOx emissions were measured with a chemiluminescent NO/NOx analyzer from Beckman (model 951A). CO was measured with infrared analyzers from MSA and Bendix. Methane was measured with a gas chromatograph (Bendix 8205 methane analyzer). Aldehydes were measured by high pressure liquid chromatography (HPLC) and are reported as formaldehyde. See Appendix 2 for more details. Gaseous methanol was measured by a gas chromatograph (a Perkins-Elmer model 3920 or Hewlett Packard model 5880A).

The test fuel which has been used is pure methanol. Five batches of the fuel have been used, and one has been analyzed. The fuel analysis is presented in Appendix 3.

FTP Test Results

The Rabbit has been tested with a total of eleven different catalysts. Those catalysts are described in Table 1. In Table 1, the catalysts have been referred to by an an Abbreviated Catalyst Code. The original catalyst on the vehicle contained platinum and rhodium in 5:1 ratio at a loading of 40 grams per

Table 1

Catalysts Tested to Date

Abbreviated Catalyst Code	CPSI and t_{wall} $[1/in^2]$ [mils]	Substrate Size [Diameter and Length]	Substrate Volume $[in^3]$	Noble ----Metals---- Ratio	Load $[g/ft^3]$	Major Base Metals
5 Pt: Rh(40)	300,10.5	4.0" x 6.0"L	75	5Pt:1Rh	40	
12 Pt: Rh(40)	400,6	4.0" x 6.0"L	75	12Pt:1Rh	40	
12 Pt: Rh(40)*	400,6	3.18" x 6.68" x 6.0"L	110	12Pt:1Rh	40	
3 Pt: 2 Pd(20)	400,6	4.0" x 6.0"L	75	3Pt:2Pd	20	
Pd (40)	400,6	4.0" x 6.0"L	75	Pd	40	
Pd + BM (35)	400,6	4.0" x 6.0"L	75	Pd	35	Proprietary transition elements
Cu	N/A	4.25" x 12.0"L	170	None		Copper mesh (1919 grams)
Pd (20)	400,6	4.0" x 6.0"L	75	Pd	20	
Ag (150)	400,6	4.0" x 6.0"L	75	Ag	150	
CU after acid dip	N/A	4.25" x 12.0"L	170	None		Acid dipped copper mesh (1910 grams)
Pd+BM (5)	400,6	4.0" x 6.0"L	75	Pd	5	Proprietary

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*This catalyst is a "racetrack" in cross section. All other catalysts are circular in cross section.

cubic foot of substrate volume. As an example of the Abbreviated Catalyst Code, this catalyst has been referred to as catalyst 5Pt:Rh(40). Also, the vehicle has been periodically tested with no catalyst to assure that major changes in emissions without a catalyst have not occurred over the duration of the test program. The vehicle emissions with no catalyst as a function vehicle odometer reading are shown in Figures 1 and 2. There was an oxygen sensor change to the emission control system which may have resulted in a slight shift in FTP emissions at about 6,300 miles; however, HC, CO, and NOx emissions have been reasonably stable over the test program to date.

Aldehyde emissions were not as stable as desired. The cause of variablity in the aldehyde emissions is being investigated. We know the column was changed in the liquid chromatograph (to a nominally identical column) just prior to generating the value of about 130 mg/mi in Figure 2. The impact of the column change on the results is unknown. It is possible that the aldehyde emissions are of such a small magnitude that we may not be able to get rid of the variability with this particular vehicle and test equipment.

All catalysts in the group are of identical volume except for the 12Pt:Rh(40)* catalyst and the two Cu catalysts. The 12Pt:Rh(40)* catalyst is a sample of 110 in^3. Initially we planned to test all samples in two volumes; however, the smaller noble metal samples were so active that increased catalyst volume would likely be able to provide little improvement in low mileage conversion efficiency. If durability testing is unsuccessful, then larger catalyst volumes may be one of several possible paths to take in an attempt to improve durability performance.

FIG. 1
EMISSIONS WITHOUT CATALYST
0% O 2

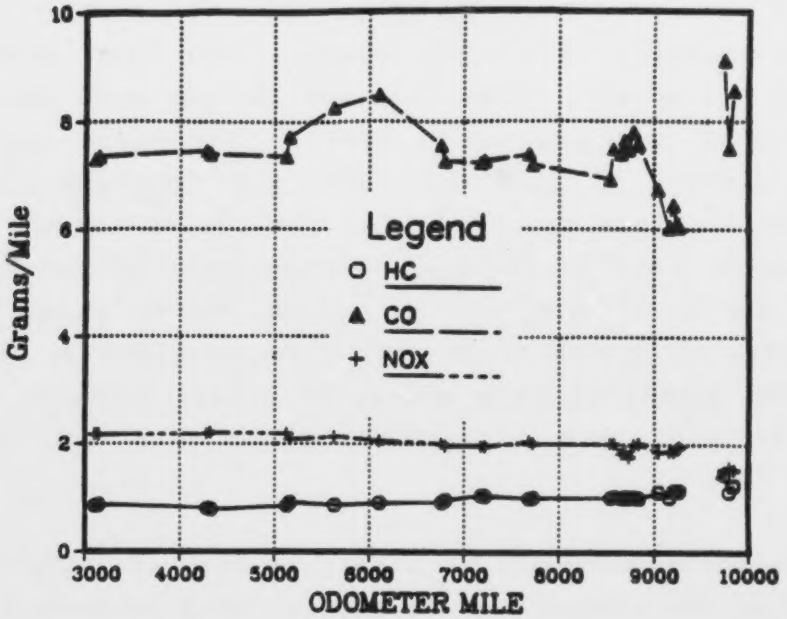
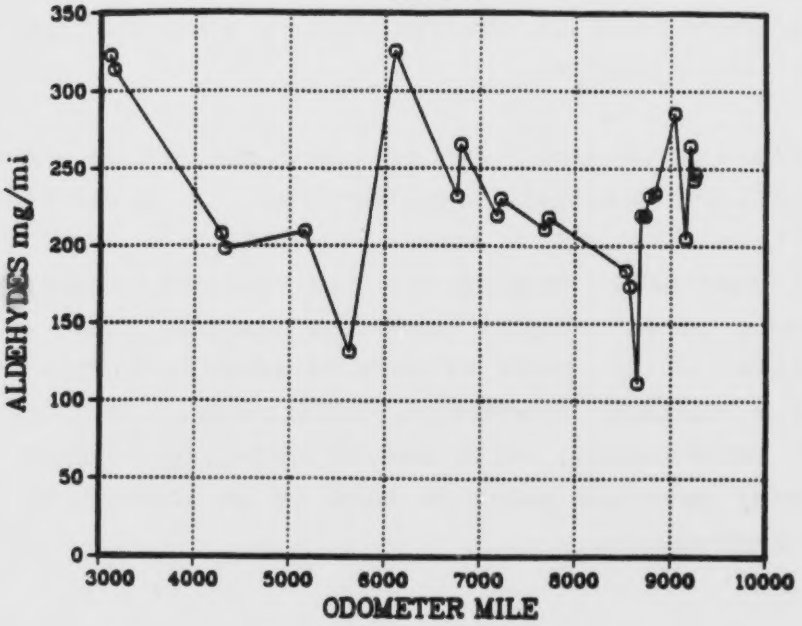


FIG. 2
ALDEHYDES WITHOUT CATALYST
0% O 2



All catalysts used in the program were zero mile catalysts except for the original catalyst on the vehicle. Assuming this catalyst had been on the vehicle since manufacture, it had accumulated less than 3,000 miles prior to testing at EPA.

Tailpipe emissions from this vehicle with no catalyst at stoichiometric operating conditions averaged 0.98 HC, 7.27 CO, 2.00 NOx. These simultaneous CO and NOx levels are low for a gasoline-fueled engine operating at stoichiometry with no EGR, even in a 2250 lb vehicle.

Tables 2 and 3 present summaries of the FTP results which were obtained at each exhaust oxygen level. Non-methane HC results are nearly identical to total HC results at all three oxygen levels with and without catalysts. (See Appendix 5.) This indicates that there is virtually no methane in the exhaust. Average FTP HC and CO emssions are below levels of 0.2 HC, 2.0 CO at all oxygen levels for all catalysts except the silver (Ag), both copper (Cu), and the first of two mixed metal (Pd + BM(35)) catalysts.

Aldehyde emissions were affected much like HC emissions by the catalysts. As shown in Figure 3 all the noble metal catalysts showed reductions in aldehydes. Aldehyde levels generally increased as exhaust oxygen level increased. Emissions of HC, CO, NOx, and aldehydes with each catalyst are shown as functions of exhaust oxygen level in Figures 4 through 14.

Individual emission test results are presented in Appendix 4. Additional statistics, including standard deviations that correspond to the the mean values in Tables 2 and 3 are shown in Appendix 5. A listing of unscheduled vehicle maintenance is provided in Appendix 6.

Table 2

Summary of FTP Emissions at Different Oxygen Levels

Catalyst	HC (g/mi) Oxygen 0%	HC (g/mi) Oxygen 3%	HC (g/mi) Oxygen 5%	Aldehydes (mg/mi) Oxygen 0%	Aldehydes (mg/mi) Oxygen 3%	Aldehydes (mg/mi) Oxygen 5%	Methanol (g/mi) Oxygen 0%	Methanol (g/mi) Oxygen 3%	Methanol (g/mi) Oxygen 5%
None	.98	.92	.90	228.3	247.0	206.9	2.18	2.08	2.46
5Pt:Rh(40)	.15	.14	N/A	20.3	15.4	N/A	.21	.59	N/A
12Pt:Rh(40)	.11	.12	.12	11.6	15.6	21.0	.33	.31	.32
12Pt:Rh(40)*	.13	.13	.13	11.4	14.4	20.8	.82	N/A	N/A
3Pt:2Pd(20)	.15	.16	.19	29.5	72.9	117.4	N/A	.28	.36
Pd(40)	.17	.14	.16	41.5	68.0	141.9	.35	N/A	N/A
Pd + BM(35)	.28	.28	.37	118.8	129.4	279.5	N/A	N/A	N/A
Cu	.90	.90	.87	291.9	322.3	313.9	N/A	N/A	N/A
Pd(20)	.18	.15	.13	41.0	94.2	104.0	N/A	N/A	N/A
Ag(150)	.54	.43	.59	59.3	52.0	37.0	N/A	N/A	N/A
None, Insulated Exhaust**	1.27	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cu, Acid Dipped**	.79	.93	N/A	425.8	460.7	N/A	N/A	N/A	N/A
Pd + BM(5)**	.19	.18	.22	N/A	N/A	N/A	N/A	N/A	N/A

N/A means data are not available
*Racetrack, others are round
**with insulation of the exhaust

Table 3

Summary of FTP Emissions at Different Oxygen Levels

Catalyst	CO (g/mi) ------Oxygen------ 0%	 3%	 5%	NOx (g/mi) ------Oxygen------ 0%	 3%	 5%
None	7.27	7.26	7.51	2.00	2.09	2.09
5Pt:Rn(40)	.78	.60	N/A	.84	1.95	N/A
12Pt:Rh(40)	.69	.39	.40	.62	2.01	2.10
12Pt:Rh(40)*	.77	.40	.46	.76	2.05	2.09
3Pt:2Pd(20)	1.47	.35	.40	.85	2.07	2.03
Pd(40)	1.99	.38	.36	.74	1.98	2.05
Pd + BM(35)	2.85	2.05	3.66	1.97	1.95	1.94
Cu	7.52	7.29	6.93	1.88	1.82	1.82
Pd(20)	1.84	.40	.31	.67	1.90	1.91
Ag(150)	6.53	5.93	7.01	2.03	1.99	1.95
None, Insulated Exhaust**	8.40	N/A	N/A	1.54	N/A	N/A
Cu, Acid Dipped**	5.88	6.31	N/A	1.76	1.99	N/A
Pd + BM(5)**	1.21	.55	.70	.83	1.80	1.84

N/A means data are not available
*Racetrack, others are round
**with insulation of the exhaust

Average FTP methanol emissions ranged from 0.21 to 0.82 gram per mile at stoichiometric exhaust conditions and with catalysts. At tne 3 percent and 5 percent oxygen levels, methanol emissions with the catalysts ranged from 0.28 to 0.59 gram per mile.

The catalysts which contain rhodium were expected to have significant NOx activity when operated as 3-way catalysts. The other noble metal catalysts also had good NOx activity in these low mileage tests. Based on the performance of vehicles fueled with gasoline, this activity may not be retained over substantial mileage accumulation with the catalysts not having rhodium. As expected, none of the catalysts provided NOx activity under oxidizing exhaust conditions.

Catalyst efficiencies were calculated for each catalyst at each exhaust oxygen level. The results of these calculations are presented in Tables 4 and 5. Catalyst efficiency as used here is defined as average tailpipe emissions with no catalyst minus average tailpipe emissions with a catalyst, the difference divided by average tailpipe emissions with no catalyst.

HC efficiencies are greater than or equal to 79% for the noble metal catalysts, except silver, at all exhaust oxygen conditions. HC efficiency was not changed much by oxygen level. CO efficiencies exceed 73 percent for all noble metal catalysts, except silver, at all oxygen conditions. CO efficiency improved at oxygen levels greater than stoichiometry.

FIGURE 3. Comparison of Aldehyde Emissions by Oxygen Level for Each Catalyst

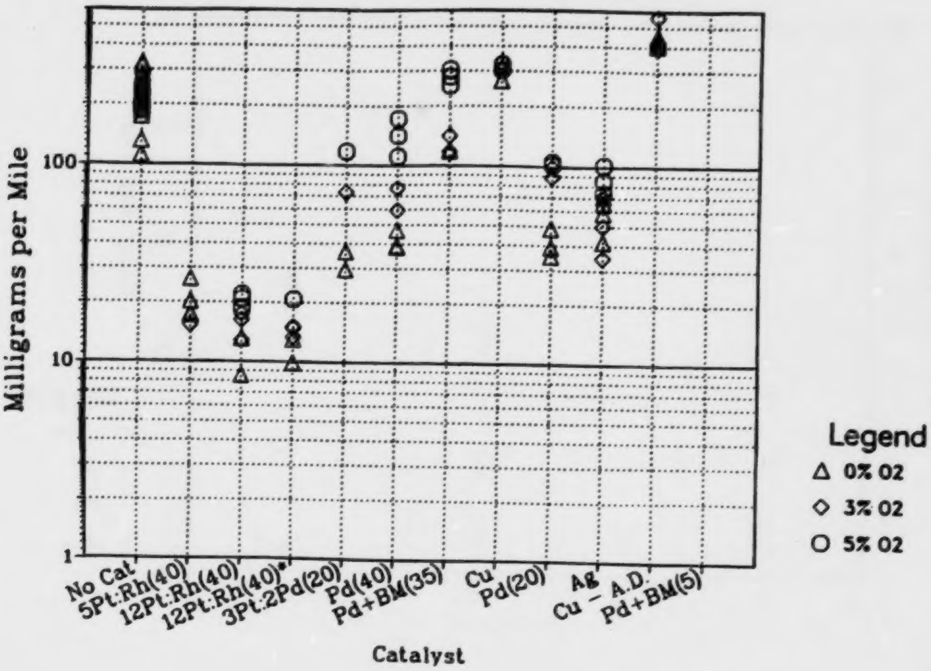


FIG 4: CAT NO. STOCK
5PT:Rh(40)

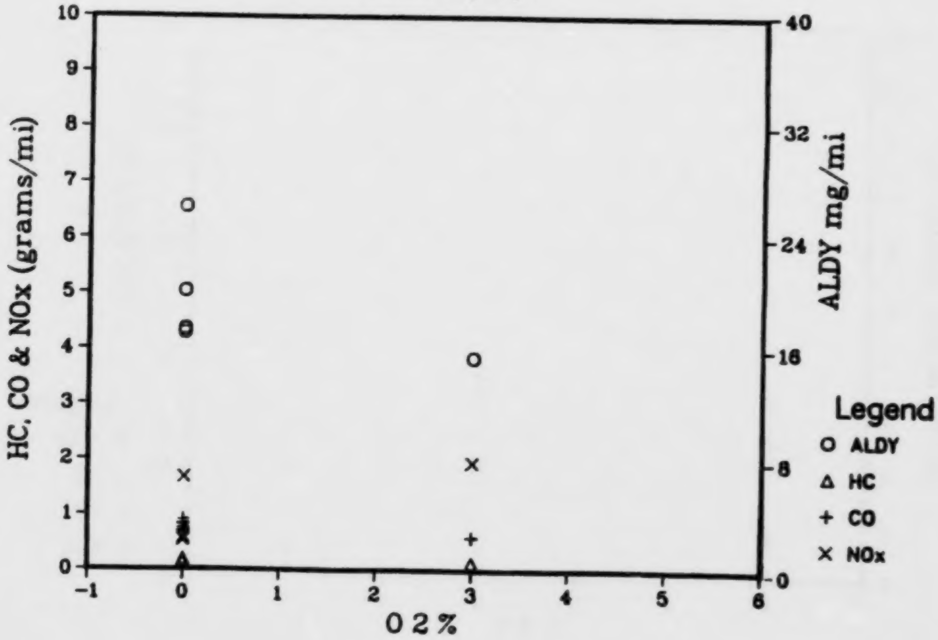


FIG 5: CAT NO. #01
12PT:Rh(40)"

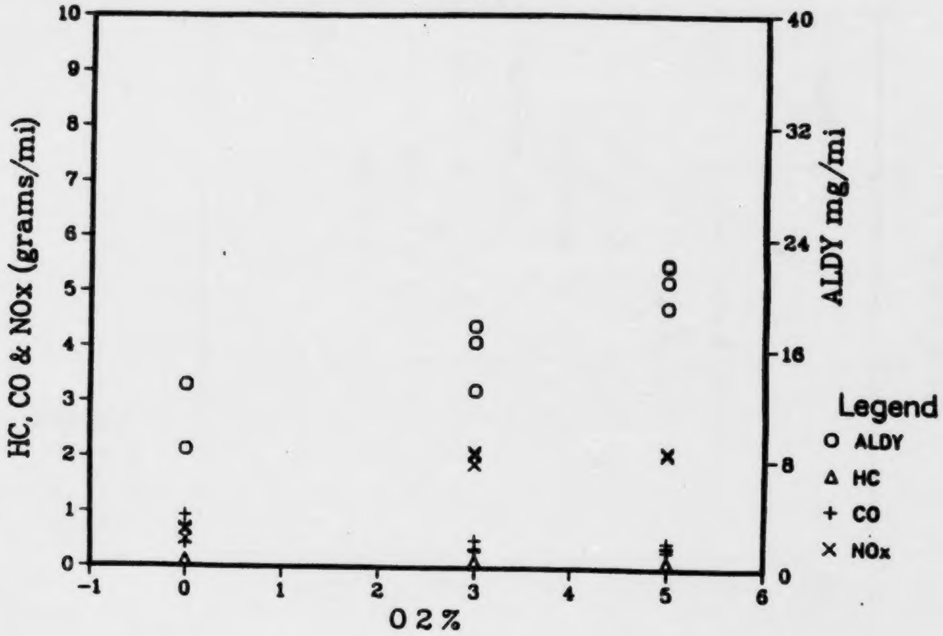


FIG 6: CAT NO. #02
12PT:Rh(40)*

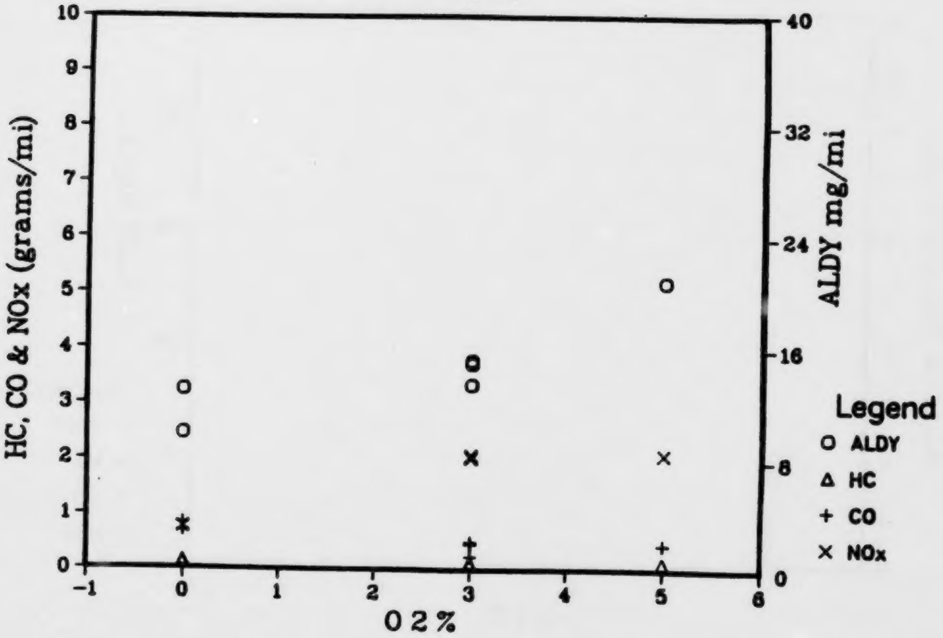


FIG 7: CAT NO. #03
3PT:2Pd(20)

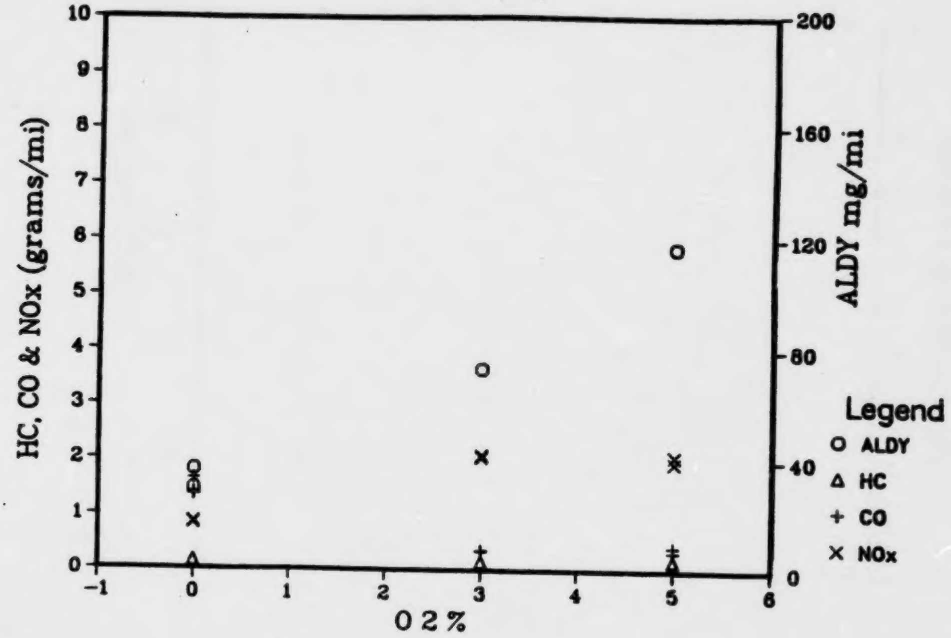


FIG 8: CAT NO. #04
Pd(40)

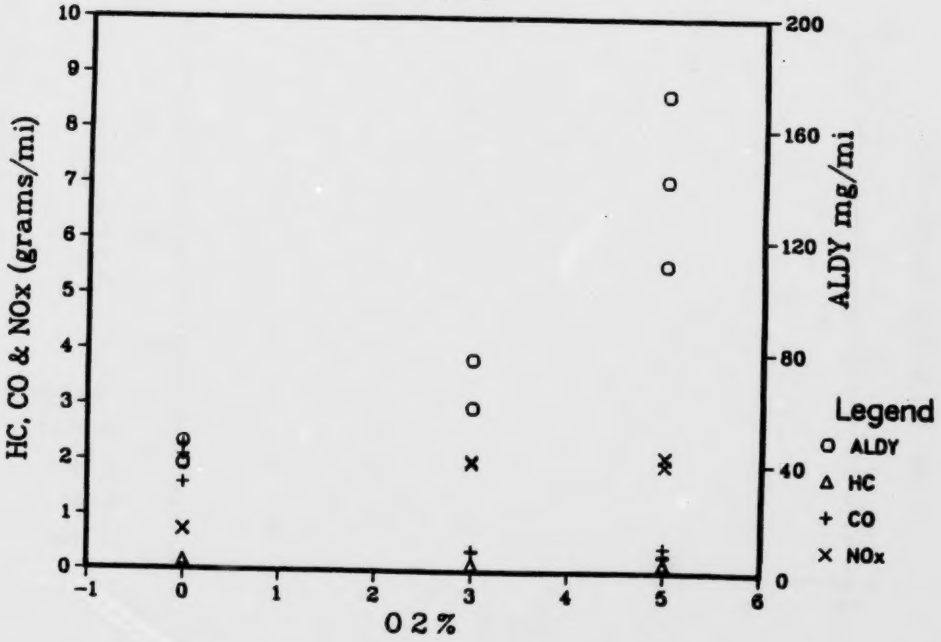


FIG 9: CAT NO. #05
Pd + BM(35)

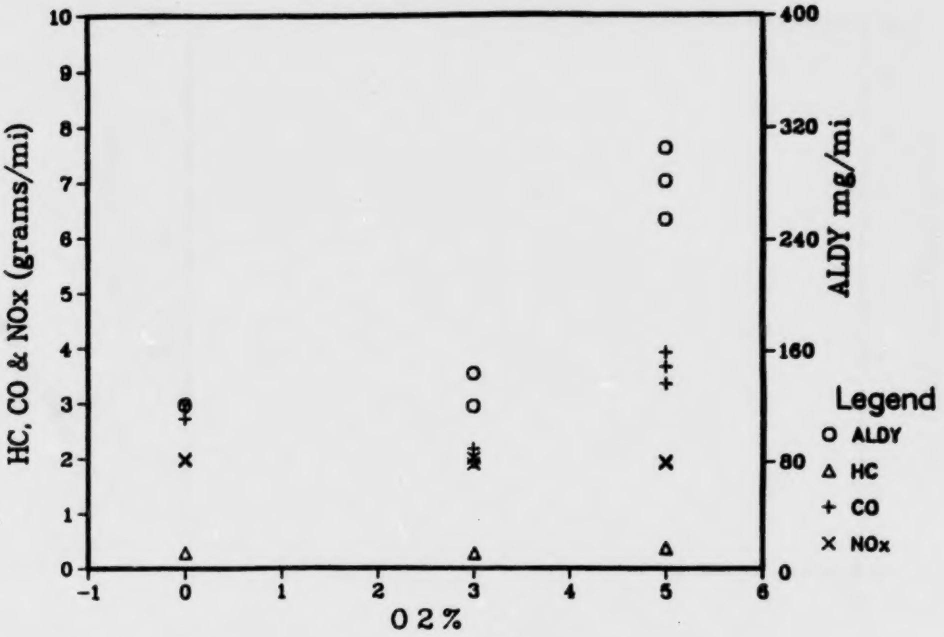


FIG 10: CAT NO. #06
Cu

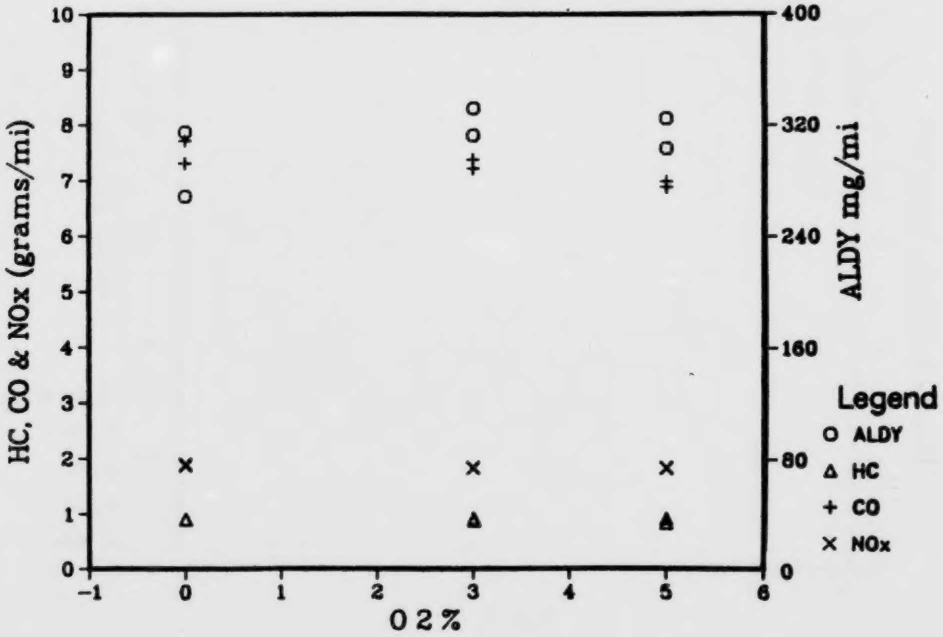


FIG 11: CAT NO. #07
Pd(20)

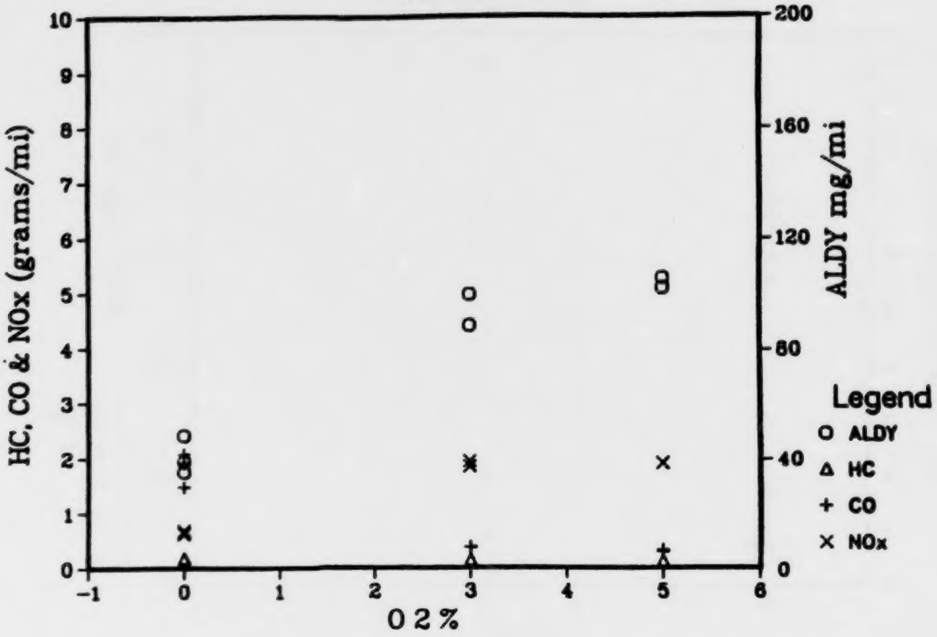


FIG 12: CAT NO. #08
Ag

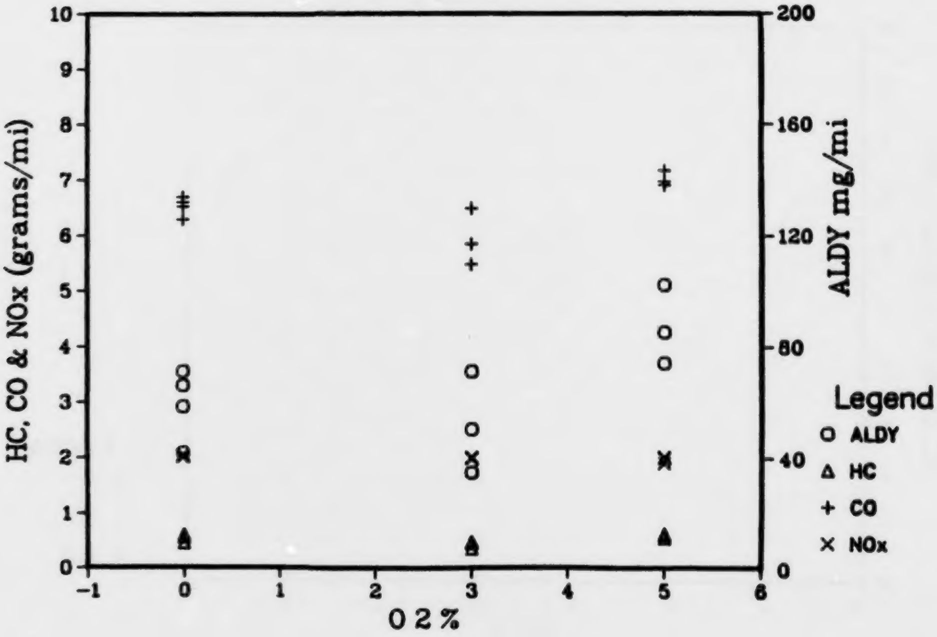


FIG 13: CAT NO. #09
Cu – Acid Dipped

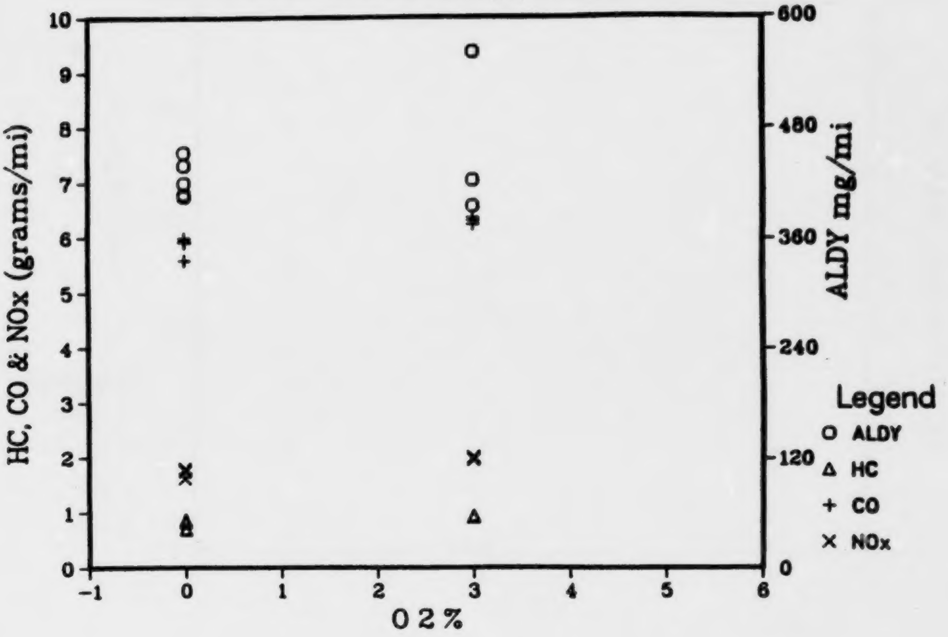


FIG 14: CAT NO. #10
Pd + BM(5)

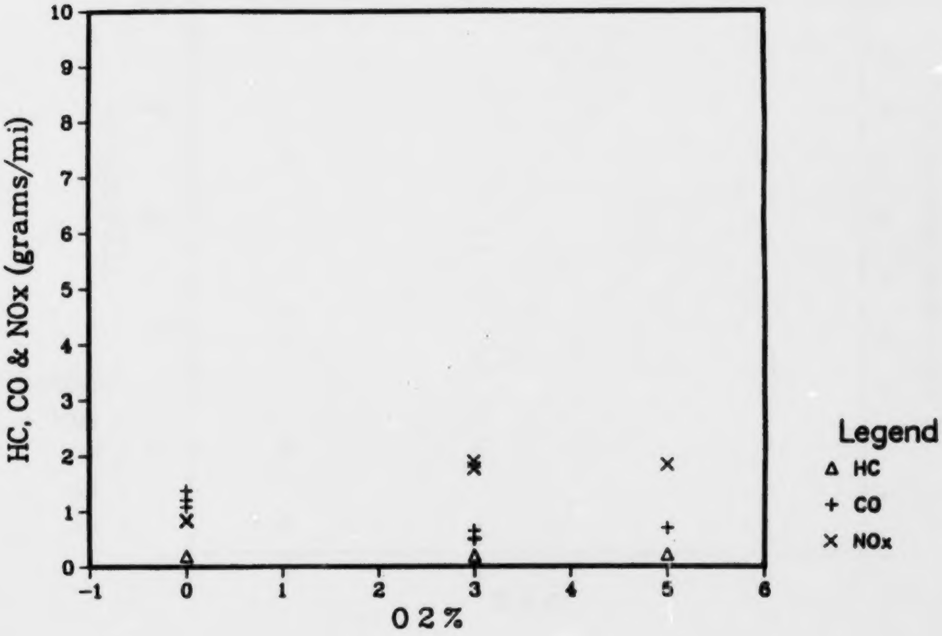


Table 4

CATALYST EFFICIENCY (%) at Different Oxygen Levels

Catalyst	HC Efficiency			Aldehydes			Methanol		
	------Oxygen------			------Oxygen------			------Oxygen-----		
	0%	3%	5%	0%	3%	5%	0%	3%	5%
5Pt:Rh(40)	85	85	N/A	91	94	N/A	91	72	N/A
12Pt:Rh(40)	89	87	87	95	94	90	85	85	87
12Pt:Rh(40)	87	86	86	95	94	90	62	N/A	N/A
3Pt:2Pd(20)	85	83	79	87	71	43	N/A	87	85
Pd(40)	83	85	82	82	72	31	84	N/A	N/A
Pd + BM(35)	71	70	59	48	48	-35	N/A	N/A	N/A
Cu	8	2	3	-28	-30	-52	N/A	N/A	N/A
Pd(20)	82	84	86	82	62	50	N/A	N/A	N/A
Ag(150)	45	53	34	74	79	58	N/A	N/A	N/A
Cu, Acid Dipped**	38	-1***	N/A	N/A	-87***	N/A	N/A	N/A	N/A
Pd + BM(5)**	85	80***	76***	N/A	N/A	N/A	N/A	N/A	N/A

N/A means data are not available
*Racetrack, others are round
**With exhaust insulation
***Efficiency is based on no catalyst emissions without exhaust insulation

Table 5

CATALYST EFFICIENCY (%)
at Different Oxygen Levels

	CO Efficiency			NOx Efficiency		
	------Oxygen------			------Oxygen------		
Catalyst	0%	3%	5%	0%	3%	5%
5Pt:Rh(40)	89	92	N/A	58	7	N/A
12Pt:Rh(40)	91	95	95	69	4	0
12Pt:Rh(40)*	89	94	94	62	2	0
3Pt:2Pd(20)	80	95	95	58	1	3
Pd(40)	73	95	95	63	5	2
Pd + BM(35)	61	72	51	2	7	7
Cu	-3	-1	8	6	13	13
Pd(20)	75	94	96	66	9	9
Ag(150)	10	18	7	-2	5	7
Cu, Acid Dipped**	30	13***	N/A	-14	5***	N/A
Pd + BM(5)**	86	92***	91***	46	14***	12***

N/A means data are not available
*Racetrack, others are round
**With exhaust insulation
***Efficiency is based on no catalyst emissions without exhaust insulation

The lowest NOx efficiency for these catalysts (again excluding silver) is 59 percent at stoichometry. Low or zero NOx efficiency is achieved during oxidizing conditions. Aldehyde efficiencies decrease as oxygen level increases. Aldehyde efficiency exceeds 64 percent for oxygen levels up to 3 percent. If rhodium is used in the catalyst, aldehyde efficiency is 89% or higher at all oxygen levels.

The copper catalyst has little impact on any FTP emission. The second copper catalyst is just slightly more active. The increased activity may be the result of increased exhuast temperature (with insulation) or the result of the acid dip. The silver catalyst has 74 percent aldehyde efficiency at 0 percent oxygen and has modest (45%) HC efficiencies.

The first palladium plus base metal (Pd + BM(35)) catalyst does not exhibit the NOx efficiency of other Pd catalysts. Also, the HC and CO efficiencies are poorer than for other catalysts which contain Pd. Apparently the amount of palladium present was not utilized as well in this catalyst as in the others. The second palladium plus base metal (Pd + BM(5)) catalyst looks very promising and may be a good candidate for later durability testing.

Evaporative Emissions

A series of SHED tests measuring evaporative emissions were performed in order to determine the effectiveness of activated charcoal canisters in controlling the evaporative emissions of methanol. The results of those tests are summarized in Table 6.

The first six SHED tests, performed on the car equipped with its stock canister, results in average evaporative emissions of 1.74 grams per test. In order to determine the effectiveness of the canister system, two additional SHED tests were performed with the canister vent lines disconnected and vented to the atmosphere. The results of those two tests averaged 1.73 grams per test. Those results seemed to indicate that the original canister was not (at that time) effective in controlling evaporative emissions. Since that lack of effectiveness might have resulted from the canister being saturated, additional testing was performed with the car equipped with new canisters. These tests also yielded results which were of the same order of magnitude. Thus, it appears that the activated charcoal canisters used in these tests are ineffective in controlling evaporative emissions from this methanol-fueled vehicle.

The flame ionization detector (FID) measurements in Table 6 were "corrected" to reflect the assumption that all the HC detected was in the form of methanol (CH_3OH), having a molecular weight of 32.04243. No attempt was made to further "correct" the table values to account for the fact not all the methanol is being measured by the FID. The relative response of the FID to methanol as compared to propane (the hydrocarbon commonly used to calibrate the FID response) has been found to range from 0.73 to 0.85 [3, 4, 5, 6].

Table 6

Evaporative Emissions*

Test Number	Test Date	----grams per test---- Heat Build	Hot Soak	Total	Comments
814597	07-08-82	1.0046	1.1030	2.1076	Stock canister (#1)
814678	07-09-82	0.6759	1.0740	1.7499	
814677	07-13-82	0.6618	0.3795	1.0413	
815125	07-30-82	0.8749	1.4208	2.2957	
815163	08-03-82	0.6897	1.0062	1.6959	
815208	08-04-82	0.6708	0.8638	1.5346	
816706	10-27-82	0.7096	0.9141	1.6237	Canister vent lines disconnected
816731	10-28-82	1.0334	0.8125	1.8459	
817499	01-20-83	0.7571	0.7447	1.5018	New canister (#2)
818980	03-25-83	0.8120	0.8512	1.6632	Canister #1 reattached
818982	03-29-83	0.7250	1.0663	1.7913	New canister (#3)
818984	03-30-83	0.7674	0.9322	1.6997	Canister #2 reattached
818986	03-31-83	0.8133	0.8961	1.7094	
818988	04-05-83	0.6585	0.7783	1.4368	
818994	04-08-83	0.7167	0.9193	1.6360	Canister vent lines disconnected

---

* FID data "corrected" by assuming all hydrocarbons detected were methanol, having a molecular weight of 32.04243.

Highway Cycle Emissions

The noble metal catalysts, with the exception of silver, provide excellent HC and CO emissions over the highway test as shown in Tables 7 and 8. HC emissions are .010 g/mi or less under all oxygen conditions. CO emissions are also very low at 0.33 or less. As on the FTP, NOx is substantially reduced by the noble metal catalysts, except silver, during stoichiometric exhaust conditions.

The mixed metal catalysts performed well on the highway test. With the Pd + BM (35) catalyst HC and CO were highest at stoichiometry where they were .016 and 1.48 g/mi respectively. Some NOx reduction was also seen. With the second mixed metal catalyst, designated Pd + BM (5), HC was less than 0.02, and CO was less than 0.2 for all oxygen levels.

The copper catalyst showed some HC activity over the highway test. The HC activity increased as the exhaust oxygen level increased. CO, aldehydes, and NOx emissions were not strongly impacted by the copper catalyst. The silver catalyst has substantial HC and modest CO activity. Aldehyde emissions were only measured at stoichiometry, and they were very low (less than 3 mg/mi).

The copper and silver units have shown improved emission control capabilities over the highway cycle as compared to the FTP. Apparently the lack of a cold start and/or the higher catalyst inlet temperatures are making the catalysts more active. The second copper mesh catalyst was tested with Kaowool insulation on the exhaust manifold, exhaust pipe, and catalyst can. This catalyst had substantially more activity over the highway test than the previous copper catalyst, possibly due to the higher temperatures or the acid dip.

Table 7

Summary of Highway Emissions at Different Oxygen Levels

	HC (g/mi) ------Oxygen------			Aldehydes (mg/mi) ------Oxygen------			Methanol (g/mi) ------Oxygen-----		
Catalyst	0%	3%	5%	0%	3%	5%	0%	3%	5%
None	.434	.407	.398	146.5	159.7	138.0	.693	0.927	0.872
5Pt:Rh(40)	.002	N/A	N/A	.2	N/A	N/A	.004	N/A	N/A
12Pt:Rh(40)	.003	.009	.010	.5	1.2	1.9	.009	.004	.006
12Pt:Rh(40)*	.008	.009	.010	1.2	2.0	2.2	.034	.014	.027
3Pt:2Pd(20)	.007	.010	.010	1.0	1.7	3.0	N/A	.014	.009
Pd(40)	.006	.008	.009	.7	1.8	2.7	.016	N/A	N/A
Pd + BM(35)	.016	.013	.014	3.1	3.0	14.5	N/A	N/A	N/A
Cu	.304	.200	.150	130.7	137.2	124.2	N/A	N/A	N/A
Pd(20)	.009	.008	.009	1.9	2.7	2.9	N/A	N/A	N/A
Ag(150)	.024	.019	.023	2.4	1.9	4.9	N/A	N/A	N/A
None, Insulated Exhaust**	.403	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cu, Acid Dipped**	.030	.033	N/A	153.5	99.8	N/A	N/A	N/A	N/A
Pd + BM(5)**	.007	.012	.014	N/A	N/A	N/A	N/A	N/A	N/A

N/A means data are not available
*Racetrack, others are round
**With exhaust insulation

Table 8

Summary of Highway Emissions at Different Oxygen Levels

	CO (g/mi)			NOx (g/mi)		
	------Oxygen------			------Oxygen------		
Catalyst	0%	3%	5%	0%	3%	5%
None	6.31	6.21	6.30	2.69	2.81	2.84
5Pt:Rh(40)	.11	N/A	N/A	.09	N/A	N/A
12Pt.Rh(40)	.05	.005	.002	.61	2.73	2.78
12Pt.Rh(40)*	.06	.025	.028	.55	2.84	2.80
3Pt:2Pd(20)	.22	.006	.004	.64	2.77	2.78
Pd(40)	.33	.012	.012	.51	2.65	2.72
Pd + BM(35)	1.48	.046	.416	1.63	2.60	2.64
Cu	6.91	6.42	6.18	2.41	2.28	2.21
Pd(20)	.38	.004	.002	.35	2.54	2.61
Ag(150)	4.26	3.47	5.12	2.74	2.64	2.51
2.51						
None, Insulated Exhaust**	5.32	N/A	N/A	2.27	N/A	N/A
Cu, Acid Dipped**	2.98	2.58	N/A	2.18	2.55	N/A
Pd + BM(5)**	.17	.003	.006	.93	2.65	2.64

N/A means data are not available
*Racetrack, others are round
**with insulation of the exhaust

Exhaust emissions over various steady state conditions were also measured in our testing. These results, from idle to 30 mph, are summarized in Appendix 7.

Cost and Efficiency per Dollar Estimates

An estimate of the sticker cost of each catalyst in this study has been generated using the methods of reference 7. Sticker cost means the cost to the consumer of the catalyst as it is reflected on the sticker of a new automobile at an automobile dealership. The information in reference 7 has been updated to use 77 percent of the current producer prices for noble metals as stated in the May 13, 1983 edition of American Metal Market - Metalworking News Edition and to account for inflation between 1977 and 1983 at an estimated rate of ten percent per year. We use 77 percent of producer price for noble metals to account for what we estimate are the discounts to the automobile manufacturers due to high volume, long term purchases.

Each catalyst has been evaluated as an oxidizing and 3-way catalyst on an "efficiency per dollar" basis. This means that for an oxidizing catalyst, the previously calculated catalyst efficiencies for HC, CO, and aldehydes over the FTP were summed and then the total was divided by the estimated sticker cost. The only difference in the calculation for 3-way catalysts is that catalyst efficiency for NOx is added to the HC, CO, and aldehyde efficiencies.

The results of these calculations are presented in Table 9. The estimated sticker costs of the catalysts in our program range from $58 to $150. The costs shown in Table 9 indicate more accuracy in our cost estimates than we generally convey to

Table 9

Sticker Cost and Efficiency per Dollar of Each Catalyst

Catalyst	Sticker Cost ($)	--Percent Efficiency Per Dollar at-- 0% Oxygen	3% Oxygen	5% Oxygen
5Pt:Rh(40)	111	3	2	N/A
12Pt:Rh(40)	110	3	3	2
12Pt:Rh(40)*	150	2	2	2
3Pt:2Pd(20)	75	4	3	3
Pd(40)	72	4	4	3
Pd + BM(35)	70**	3	3	1
Cu	58	0	-1	-1
Pd(20)	64	5	4	4
Ag(150)	65	2	2	2
Cu, Acid Dipped***	58	-1	-1	N/A
Pd + BM(5)***	58**	4****	3****	3****
Canned substrate only, no catalyst	56	N/A	N/A	N/A

---

* Racetrack, others are round

** Does not include the cost of base metals.

*** Tested with exhaust insulation; efficiency is based on no catalyst emissions without insulation.

****Does not include catalyst efficiency for aldehydes. (Aldehyde data are not yet available.)

the reader. Normally we would round these costs off to the nearest 5 or 10 dollars. In this case, rounding to the nearest 5 dollars would mask real cost differences in the catalysts and would make non-identical catalysts appear to cost the same amount.

Strictly on the basis of the efficiency per dollar calculations, durability selection for 3-way catalysts would be made in the following order of decreasing interest:

Pd(20),
Pd(40),
3Pt:2Pd(20),
Pd + BM(5)
12Pt:Rh(40),
5Pt:Rh(40),
Pd + BM(35),
12Pt:Rh(40)*,
Ag(150),
Cu, and
Cu - Acid Dipped.

Additional considerations could be included, however, in the selection of durability candidates. First, we must consider that virtually all 3-way catalysts used for gasoline-fueled vehicles contain rhodium. This indicates that rhodium is likely needed for adequate NOx emission control at high mileage. The second consideration is that durability testing is so costly that we may want to test samples with the highest probability of success, not the samples with least cost.

The Pd + BM(5) catalyst might be a candidate for durability testing depending on its (not yet determined) efficiency for aldehydes. Durability testing with other samples is not recommended. The samples designated Cu, Ag(150), 12Pt:Rh(40)*, and Pd + BM were omitted on the basis of low efficiency per dollar. The Pd(20) unit was omitted because it is like the Pd(40) catalyst in all respects except that it contains only half as much palladium.

For durability operation as oxidizing catalysts, efficiency per dollar would dictate selections in this order:

at 3% Oxygen	at 5 % Oxygen
Pd(20),	Pd(20),
Pd(40),	Pd(40),
3Pt:2 Pd(20),	3Pt:2Pd(20),
Pd + BM(5)	Pd + BM(5)
Pd + BM(35),	12Pt:Rh(40),
12Pt:Rh(40),	
5Pt:Rh(40),	12Pt:Rh(40)*,
Ag(150),	Ag(150),
12Pt:Rh(40)*,	Pd + BM(35), and
Cu, and	Cu.
Cu - Acid Dipped.	

The selections at 3 percent and 5 percent oxygen are in nearly the same order. Except for the Pd + BM(35) catalyst and two less catalysts to evaluate at 5% oxygen, the order is practically the same.

Since rhodium content has not been of importance in oxidizing catalyst durability with gasoline-fueled vehicles, our recommendations for durability evaluation of oxidizing catalysts follow the efficiency per dollar calculations more closely. For durability testing as oxidizing and 3-way catalysts we have selected the following catalysts:

Pd(20), and
3Pt:2Pd(20).

The Pd(40) sample was deleted since it is identical to the Pd(20) sample except that it has twice as much palladium. Any problems with emissions durability in theory should be more apparent with the Pd(20) catalyst than with the Pd(40) catalyst. As additional catalysts complete the low mileage testing, additional catalysts may be identified for later durability evaluation.

Summary

Over the FTP:

- Almost no methane is measured in the exhaust.
- Excellent HC and CO control (less than 0.2 and 2.0 grams per mile, respectively) is achieved with all the noble metal catalysts, except silver, at all exhaust oxygen levels.
- All the noble metal catalysts, except silver, achieve NOx levels below 1.0 gram per mile at stoichiometry.
- Catalysts which contain rhodium provide for formaldehyde conversion efficiencies which are very high at all exhaust oxygen levels.
- The addition of the first combination of base metals to a Pd catalyst did not improve catalyst performance; however, the second combination of base metals did appear to improve the catalyst performance.
- CO and NOx control are both poor with both base metal catalysts.

Over the highway cycle:

- Exhaust emissions are generally much less than on the FTP on a gram per mile basis, except for NOx emissions. Excluding emissions with the two copper catalysts (which are the least active of all catalysts) and CO emissions with the silver catalyst, little HC, CO, or aldehyde is emitted.

Based on cost, catalyst efficiency, and other considerations, several catalysts have been identified which merit durability testing as 3-way and as oxidizing catalysts. Additional catalysts will be evaluated and additional effort will be expended to improve emissions from catalysts which have performed poorly to date.

References

1. H. Menrad, G. Decker, and K. Weidmann, "Alcohol Fuel Vehicles of Volkswagen", SAE Paper No. 820968, August, 1982, pp 9-12.

2. Status Report of Volkswagenwerk AG Audi, NSU Auto Union AG and Volkswagen of America, Inc., submitted to the Environmental Protection Agency, May, 1981, Volume 1, Section VII.

3. D.L. Hilden and F.B. Parks, "A Single-Cylinder Engine Study of Methanol Fuel - Emphasis on Organic Emissions," SAE Paper No. 760378.

4. R. Bechtold and J.B. Pullman, "Driving Cycle Economy, Emissions, and Photochemical Reactivity Using Alcohol Fuels and Gasoline," SAE Paper No. 800260.

5. H. Menrad, W. Lee, and W. Bernhardt, "Development of a Pure Methanol Fuel Car," SAE Paper No. 770790.

6. G.D. Ebersole and F.S. Manning, "Engine Performance and Exhaust Emissions: Methanol Versus Isooctane," SAE Paper No. 720692.

7. L.H. Lindgren, Cost Estimations for Emission Control Related Components/Systems and Cost Methodology Description, EPA-460/3-78-002, March, 1978, pp 131-134 and pp 147-149.

8. R. Wagner and L. Landman, "Low Mileage Catalyst Evaluation with a Methanol-fueled Rabbit - Interim Report," EPA Report No. EPA/AA/CTAB/TA/83-5, May 1983.

APPENDIX 1

Vehicle Description

ITEM	1980 PRODUCTION	METHANOL VEHICLE
Fuel System (Continued)		
o Fuel Pump		
Pump Life	- Life of Vehicle	- 6 months to 1 year due to corrosiveness of Methanol.
Other	-	- Improved insulation on wiring exposed to fuel.
o Accumulator		
Maximum holding pressure	- 2.5 Bar	- 3.0 bar (due to fuel difference).
o Fuel Filter		- Bonding glue changed for fuel compatability. - One way check valve deleted (Incompatable with fuel).
o Fuel Distributor		
System pressure	- 4.6 - 4.8 bar	- 5.0 - 5.3 bar
Calibration	- Optimized for gasoline	- Optimized for Methanol.
Other	-	- Material changes for fuel compatability.
o Air sensor	-	- Modified airflow charteristics.
o Fuel Injectors	-	- Material change for fuel compatability. - Plastic screen replaced by metal screen.
o Cold Start Injector		
Quantity	- One	- Two
Function	- On for start only.	- Cold start valves pulse for 8 seconds beyond start mode, below zero degrees centigrade.

Appendix 1

Test Vehicle Description*

A. VEHICLE DESCRIPTION

1981 Volkswagen Rabbit "L" 4-Door Sedan - Model 177243
VI# 1VWF80175BV012728 Engr. Car # 1285

Automatic transmission, air conditioning, 155 80R13 tires, radio and cloth interior. (A vehicle with Vinyl "leatherette" interior was not available at time prototype was built. This may have a small influence on evaporative losses, but this will be negligible once the "new car" background level deteriorates.)

B. DETAILED COMPARISON OF PRODUCTION vs. METHANOL POWERTRAIN AND FUEL SYSTEM

ITEM	1980 PRODUCTION	METHANOL VEHICLE
Basic Engine		
o Type	827	827
o Displacement	1.6 liter (1588cc)	1.6 liter (1588cc)
o Bore	3.13 inches	3.13 inches
o Stroke	3.15 inches	3.15 inches
o Compression Ratio	8.2:1	12.5:1 (new pistons)
o Valvetrain	Overhead camshaft	Overhead camshaft
o Rated Power	76 HP SAE net @ 5500 RPM	Not measured
o Rated Torque	82.7 Ft. lbs. SAE net @ 3200 RPM	Not measured
o Other	-	GTI basic engine - European high performance engine to withstand higher loads - U.S. cylinder head.
Fuel System	Bosch CIS Fuel Injection with Lambda feedback control.	Same as Production with calibration for Methanol operation.

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*Reproduced from Reference 2.

ITEM	1980 PRODUCTION	METHANOL VEHICLE
Fuel System (Continued)		
Other	-	- Calibration changed for Methanol. - Material changed for fuel compatability.
o Fuel Injection Wiring	-	- Modified for cold start pulse function and to accomodate relays and thermo switch.
o Air Conditioner Idle Load Compensation	- Ignition distributor vacuum advance controlled.	- Throttle body idle air flow bypass system controlled. (Same as 1982 Production)
o Idle Setting		- Specific to Methanol calibration
PCV	- PCV Valve with calibrated plunger and calibrated orifice.	- PCV valve with calibrated plunger - no orifice.
IGNITION		
o Distributor	- Transistor high energy with hall effect and digital idle speed control through spark advance.	- Slightly reduced maximum centrifugal advance and slightly modified vacuum advance/retard characteristics.
o Spark Plugs	- Bosch W175T30	- Bosch W260T2-Colder
OIL COOLING	- None	- Heat exchanged from engine oil to cooling water for high loads only (e.g. trailer hauling) not anticipated to be needed in normal operation.

TRANSMISSION	Automatic 3-Speed	Automatic 3-Speed (1981 Production Transmission)
o Torque Converter Ratio	2.44	2.44
o Stall Speed	1900-2200 RPM	2000-2200 RPM
o Gear Ratios		
1	2.55	2.55
2	1.45	1.45
3	1.00	1.00
Axle	3.76	3.57
FUEL TANK		(European)
o Material	Steel	Steel
o Coating	Terneplate	Phosphated steel, exterior painted
o Seams & Fittings	Soldered	Brazed
o Cap -	Non-Locking	European neck and locking cap
FUEL	Unleaded gasoline	Methanol with 5.5% Isopentane

APPENDIX 2

Formaldehyde Measurement

FORMALDEHYDE MEASUREMENT IN VEHICLE EXHAUST AT MVEL

Robert K. Gilkey

Measurement of exhaust formaldehyde at MVEL is performed using a DNPH (Dinitrophenylhydrazine) technique adapted from that of L.A. Hull[1]. Exhaust carbonyls (including formaldehyde) are reacted with DNPH solution forming hydrazone derivatives. The derivatives are separated directly from the DNPH solution using a liquid chromatograph (LC). Quantization is accomplished with a spectrophometer in the LC effluent stream driving an integrator unit which determines peak height and/or area.

SAMPLING SYSTEM

Figure #1 gives an overall view of the formaldehyde sampling system. Exhaust from the vehicle is ducted to the constant volume sampling (CVS) unit where it is quantitatively diluted with room air. The formaldehyde system draws off a small portion of the diluted exhaust through a probe within the CVS unit. The collection portion is attached directly to the CVS unit to keep the plumbing as short as possible. A flow measurement and control unit is mounted to the wall at the left. The sample pump is mounted to the floor under the flow unit and is not visable.

Figure #2 is a schematic of the sampling system. All of the solenoid valves are electrically connected to the CVS bag sampling switches. Activation of any one of these three switches automatically selects a unique set of impingers (bubblers) and isolates and vents the other two sets. Isolation and venting are required to prevent contamination of the CVS unit or the sample lines.

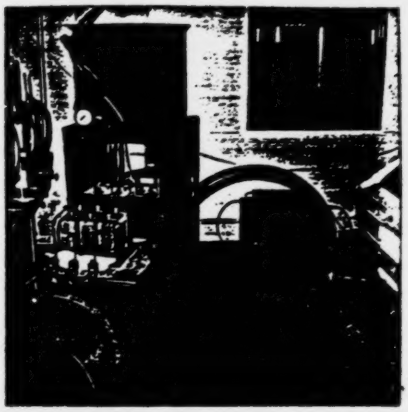

FIG 1

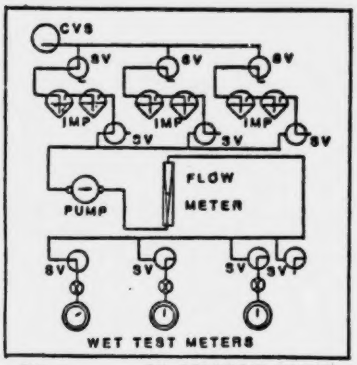

FIG 2 SV-SOLENOID VALVE
IMP-IMPINGER

The sample system is constructed of stainless steel, teflon, and glass upstream of the impingers. This part of the system is also maintained at 100°C. These precautions help prevent loss of formaldehyde within the system. Downstream of the impingers, construction materials and high temperature are not critical.

Two impingers are used in each set. Each is filled with five milliliters (ml) of DNPH solution and immersed in an ice bath during test. Two concentrations of this solution are used depending on the expected exhaust formaldehyde concentration. 0.25 g/l DNPH is used for most catalyst tests while 0.50 g/l DNPH is used for non catalyst tests. The DNPH is dissolved is slightly acidic acetonitrile (ACN).

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[1] L.A. Hull, "Procedures for 2, 4 - Dinitrophenylhydrazone Aldehyde-Keytone Air Analysis". Internal EPA, FTP memo, 1981.

Tests have shown that the efficiency of the first impinger is approximately 90% with two liters per minute sample rate.

ANALYSIS PROCEDURE

Upon completion of vehicle testing, the impingers are removed from the sampling system and refilled to 5 ml with ACN. Each impinger is permanently marked at 5 ml to facilitate this operation which restores evaporation loss. The solution is then transfered directly to a glass vial with a teflon lined septum which is compatible with the LC autosampler.

Separation of the carbonyl derivatives is done using a Waters Associates M-6000A chromatography pump with a Varian Micro pak MCH-10 reversed phase 30 cm x 4 mm column. A mixture of 65% ACN / 35% water is used as the carrier at a flow rate of 2 ml/minute. The column feeds directly into the primary absorbance cell of a Varian 635 UV-Visible spectrophotometer set to 360 nm wavelength. Sample injection is made through a 10 ul loop.

An overall view of the analysis system is shown in figure #3. The system is semi-automatic. (Baseline drift must be monitored and corrected during long runs to keep the integrator from being driven out of its range.)

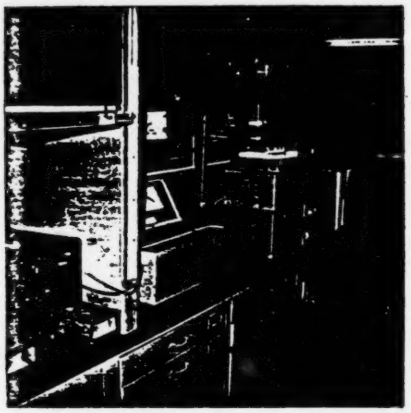


FIG 3

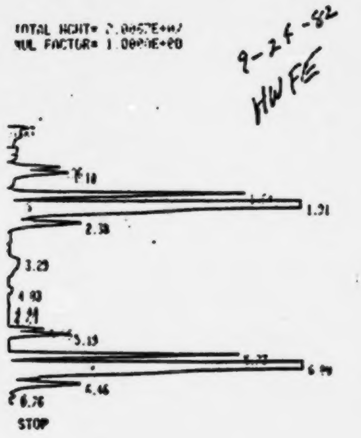
Quantification is done using peak-height rather than area. Experiments indicate better repeatablility and more consistant results with this method. The Hewlett Packard 3390A integrator permits reports in either peak-height or area or both.

Standards are run prior to each group of test vials to be analyzed. At least three are used to bracket the expected concentrations and a calibration curve is drawn. Generally this curve is linear, though corrections are made if it is not. (Non-linearity occurs when vehicle test conditions produce concentration differences greater than two orders of magnitude.)

Analysis system sensitivity is noise limited between ± 0.2 and ± 0.8 ug/ml of formaldehyde derivative. This translates roughly to 0.2 to 0.8 mg/mi for the FTP test and 0.05 to 0.25 mg/mi for the HWFE test. Repeatability is approximately ± 5% or better.

During test sample analysis, the Dupont 834 Automatic Sampler sequences a flush vial and a sample vial pair to the injection station. Every sample vial is injected twice. Each sample is allowed to elute for four minutes before the next injection or pair is introduced. The sampler will hold up to 47 pairs.

The Hewlett Packard 3390A Integrator is started upon injection of the first sample vial and allowed to run continuously until the last vial is finished. This unit generates a continuous trace of the spectrophotometer output anotated with the apparent retention time of each peak distinguished. A report is generated at the end of each run. This report gives peak information keyed to the retention time. The "formaldehyde" peaks are easily separated from the others by their relation to the DNPH peak. The integrator will hold information on over 1000 peaks which is adequate for very long runs. A typical vehicle vial analysis report is shown in Figure #4. Two injections were made of the same vial. The peaks at 2.38 and 6.46 minutes are formaldehyde/DNPH derivative. Unreacted DNPH peaks are at 1.91 and 6.00 minutes. (All three peaks preceding DNPH are tentively identified as species of NOx.) (In this case the vehicle was methanol fueled and equipped with a catalyst.) The total formaldehyde derivative concentration from the exhaust for this test was calculated as 3.1 ug/ml.



```
RUN #  13             SEP/28/82  05:00:34

HEIGHT%
   RT     HEIGHT  TYPE  AR/HT   HEIGHT%
  0.96    181463    PV  0.838     0.932
  1.10    210276  D VP  0.122     1.080
  1.64    860928   SP8  0.099     4.422
  1.91   8132900   SP6  0.133    41.774
  2.38    223822    BP  0.116     1.150
  3.29     48386    VV  0.447     0.249
  4.03     36025    VP  0.199     0.189
  4.44     24962    VV  0.170     0.128
  4.69     20429    VV  0.105     0.105
  5.96    151201    VV  0.091     0.779
  5.19     24649  D VV  0.101     1.866
  5.73    876831   SP2  0.103     4.584
  6.00   8201920    SH  0.132    42.129
  6.46    232878   TBB  0.119     1.196
  6.76     20702  D BP  0.095     0.106
```

FIG 4

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STANDARDIZATION

Standards are made by quantitative dilution from crystaline formaldehyde/DNPH derivative. This derivative (Formaldehyde 2, 4-Dinitrophenylhydrazone) is produced by reacting 40% aqueous formaldehyde solution with a hot saturated solution of 2, 4-DNPH in methanol. A drop of HCl is added and the derivative is precipitated with water. The crystals are filtered and recrystalized from a mixture of 3 parts methanol to 1 part water.

Primary liquid standards are made at 500 ug/ml and 200 ug/ml by dissolving the dried derivative in HPLC grade ACN. A micro balance is used for this operation. Successive dilution of the primary standards is used to give at least 10 concentrations down to 0.5 ug/ml. Once in solution, the standards are monitored for stability.

CALCULATIONS

Data are reported in terms of total formaldehyde per test phase and total formaldehyde per mile driven during the test phase. The primary equation is:

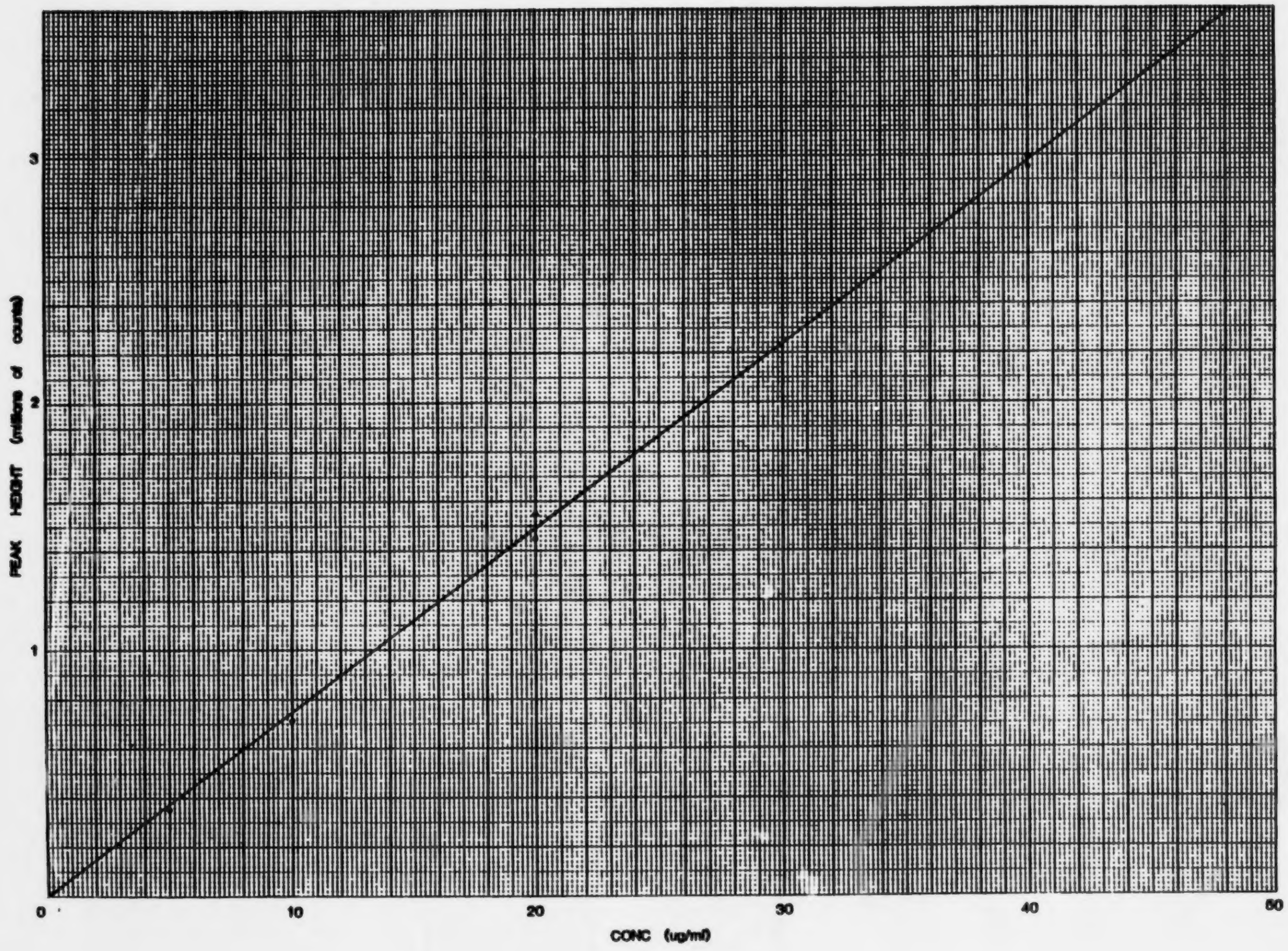
$$\mathrm{mg_F/mi} = \frac{(.004046 * \mathrm{CONC} * V_{imp} * \mathrm{VMIX})}{(\mathrm{VS} * \mathrm{D})}.$$

Where;

CONC = Concentration of derivative (ug/ml)
V_{imp} = Volume of impinger fluid (ml)
VMIX = Total CVS flow (ft^3)
VS = Volume of sample taken (l)
D = Distance driven during test (mi)

$$.004046 = \frac{\mathrm{MW_{Formaldehyde}}}{\mathrm{MW_{Derivative}}} * \frac{1/\mathrm{ft}^3}{\mathrm{ug/ml}}$$

$$= \frac{30.011}{210.04} * \frac{28.316}{1000}$$



9/28/82

CALIBRATION

"CCNC" is determined from the formaldehyde peak height counts for each sample vial. The "best" peak is chosen from the two for each vial. If both are good, the last is chosen. The calibration curve for the run is then used to obtain the concentration from the height counts. "Best" is determined from integrator peak information and visual inspection.

"Vimp" is held constant at 5 ml of DNPH sampling solution in each impinger. Evaporation of the ACN solvent during test is a problem despite the ice bath in which the impingers are placed. The loss is always made up before the solution is transfered to the sample vials. Transfer of DNPH solution between or out of the impingers due to pressure imbalances is prevented by the isolating and venting solenoids.

"VMIX" is obtained directly for each test from the CVS control unit. The value represents the total volume of dilute exhaust produced by the vehicle during a test. VMIX is presented at standard conditions of 760 mm Hg and 68.0°F.

"VS" is measured by Precision Scientific 63111 or 63115 wet test meters. The meters are calibrated at nominal MVEL pressure and temperature conditions of 736 mm Hg and 73°F to correct readings to the above conditions. Corrections to actual test conditions are minimal and are neglected.

"D" is obtained as roll revolutions from the dynamometer control unit. A calibration factor is used to convert this reading to miles. This calibration rarely changes.

"MW" (Molecular Weight) for both formaldehyde and its DNPH derivative were calculated from their molecular formulas and generally available atomic weights. The formulas are:

2, 4-Dinitrophenylhydrazine (DNPH)........ $H_2\,NNHC_6H_3(NO_2)_2$

Formaldehyde.............................. OCH_2

Formaldehyde 2, 4-Dinitrophenylhydazone... $CH_2\,NNHC_6H_3(NO_2)_2$

One mole of formaldehyde reacts with one mole of DNPH to give one mole of derivative plus one mole of water.

A standard work sheet is used to collect data and report results. The results may be calculated from the equations and conversions given on the sheet. A "BASIC" program for the Apple Computer has been developed to complement the work sheet. This program generates a calibration equation of the form: Conc = A3*(Counts)^2 + A2*(Counts) + 0. The curve is forced through zero, zero. The coefficients are then used in the reduction program presented in Figure 8.

FORMALDEHYDE ANALYSIS WORKSHEET

CH_2O Emiss = (.004046 * Conc * V_{BUB} * VMIX)/(V_S * Dist)

TEST # __________ DATE 9-24-82

	CONVERT	UNITS		Bg 1	Bg 2	Bg 3	FTP Tot	HWFE	IDLE	20 mph	30 mph	40 mph	
DMPH Vol.		ml	V_{BUB}					5					
Samp. Vol.	* 28.316	ft^3 l	V_S					0.833 23.60					
VMIX		ft^3	VMIX					4115					
Distance (Cal.)	/(RR/mi)	Roll Rev						23823 2331.57					
Distance		mi	Dist					10.218					
Defl.								232,478					
Range								Varian 0.5					
Raw Conc.		ug_D/ml	Conc					3.13					
Bag Conc.		ppm_F											
Bag Conc.		mg_F/l											
Tot. CH_2O		mg_F						11.041					
CH_2O Emiss		mg_F/mi	CH_2O E.					1.1					
Wt. FTP	Dist	mi											
	* Wt			0.5	1.0	0.5							
		Wt mi											
	Tot. CH_2O	mg_F											
	* Wt			0.43	1.00	0.57							
		Wt Tot											
	Wt Emiss.	Wt Tot / Wt mi											

FIG 6

```
]RUN FMALD.EPA
     FORMALDEHYDE DATA REDUCTION



 CAL DATA

    A(1) = 0
    A(2) = 9.55983598E-06
    A(3) = 1.59070037E-12


ARE THESE THE RIGHT COEFF'S ? (Y/N) Y



TEST DATA


             USE 'Q' TO QUIT 'R' TO REDO


 DNPH VOLUME (ML) ? 5
 VB = 5 ML

 SAMPLE VOL (CU FT OR L) ? .832
 VS = .832 CU FT
 VS = 23.558912 LITERS

 VMIX (CU FT) ? 4126
 VMIX = 4126 CU FT

 ROLL REVS ? 23926
 ROLL REVS = 23926
 DISTANCE = 10.261755 MILES

 PEAK HEIGHT COUNTS ? 217547
  PEAK HEIGHT COUNTS = 217547
 CONCENTRATION = 2.15 UG/ML

 CH20 EMISS = .74 MGM/MI

  TOTAL CH20 = 7.64 MGM

ID FOR THIS VIAL? 9-28-82 HWFE
HIT RETURN TO CONTINUE
TEST DATA


             USE 'Q' TO QUIT 'R' TO REDO
```

FIG. 7

```
]LOAD FMALDPR#0
]LIST

20 HE$ = "FORMALDEHYDE DATA REDUC
    TION"
30  REM : PR#4
40  HTAB 20 - ( LEN (HE$) / 2): PRINT
     HE$: PRINT : PRINT
80  INVERSE : PRINT "CAL DATA": NORMAL
     : PRINT
100 NS = 3
102 D$ =  CHR$ (4): REM  CONTROL
     D
104  PRINT D$;"OPEN COEFF, L45"
106  PRINT D$;"CLOSE COEFF"
108  PRINT D$;"OPEN COEFF, L45"
110  FOR I1 = 0 TO NS - 1
112  PRINT D$;"READ COEFF, R0, B"
     ;I1 * 15
114  INPUT AS(I1 + 1): NEXT I1
116  PRINT D$;"CLOSE COEFF"
118  GOTO 200
120  INPUT "    A(1) = ";AS(1)
140  INPUT "    A(2) = ";AS(2)
160  INPUT "    A(3) = ";AS(3)
180  PRINT
200  HOME : INVERSE : PRINT "CAL
     DATA": NORMAL : PRINT
220  PRINT "    A(1) = ";AS(1)
240  PRINT "    A(2) = ";AS(2)
260  PRINT "    A(3) = ";AS(3): PRINT
     : PRINT
262  INPUT "ARE THESE THE RIGHT C
     OEFF'S ? (Y/N) ";IN$
264  IF IN$ = "N" GOTO 120
266  IF IN$ <  > "Y" GOTO 262
268  PRINT : PRINT
280  HOME : INVERSE : PRINT "TEST
      DATA": NORMAL : PRINT : PRINT

290  HTAB 10: PRINT "USE 'Q' TO Q
     UIT 'R' TO REDO"
291  PRINT : PRINT
300  INPUT " DNPH VOLUME (ML) ? "
     ;VB$
320  IF VB$ = "" THEN VB$ = "5"
330  IF VB$ = "Q" THEN  END
335  IF VB$ = "R" THEN  PRINT "**
     ": GOTO 280
340  IF VB$ = "5" THEN  GOTO 400
360  INPUT " VALUE IS NORMALLY 5
     - IS YOUR VALUE GOOD ? (Y/N)
      ";IN$
365  PRINT "CHR$ (7): PRINT CHR$
     (7) REM BELL
370  IF IN$ = "5" THEN IN$ = "5":
      GOTO 400
380  IF IN$ = "N" THEN  GOTO 300
390  IF IN$ <  > "Y" GOTO 300
400 VB =  VAL (VB$): PRINT " VB =
      ":VB:" ML": PRINT
```

Fig. 8

```
420  INPUT " SAMPLE VOL (CU FT OR
      L) ? ";VS$
430  IF VS$ = "Q" OR VS$ = "R" THEN
      PRINT "**": GOTO 280
435  IF  VAL (VS$) = 0 THEN  PRINT
     "ILLEGAL VALUE-PLEASE REENTE
     R": GOTO 420
440 CK$(1) = "FT3"
460 CK$(2) = "FT"
480 CK$(3) = "F"
500  IF  RIGHT$ (VS$,1) = "L" THEN
     VS =  VAL (VS$): GOTO 660
520 :
540  FOR I = 1 TO 3
560  IF  RIGHT$ (VS$, LEN (CK$(I)
     )) = CK$(I) THEN VS =  VAL (
     VS$) * 28.316: GOTO 640
580  NEXT I
600  IF  VAL (VS$) >  = 8 THEN VS
      =  VAL (VS$): GOTO 660
620 VS =  VAL (VS$) * 28.316
640  PRINT " VS = "; VAL (VS$);"
     CU FT"
660  PRINT " VS = ";VS;" LITERS":
      PRINT
680  INPUT " VMIX (CU FT) ? ";VM$
     :VM =  VAL (VM$)
690  IF VM$ = "Q" OR VM$ = "R" THEN
      PRINT "**": GOTO 280
700  PRINT " VMIX = ";VM;" CU FT"
     : PRINT
720  INPUT " ROLL REVS ? ";RR$
725  IF RR$ = "Q" OR RR$ = "R" THEN
      PRINT "**": GOTO 280
730  IF  VAL (RR$) = 1 OR  VAL (R
     R$) = 0 THEN RR$ = "0":MI =
     1: GOTO 760
740 MI =  VAL (RR$) / 2331.57
760  PRINT " ROLL REVS = ";RR$
780  PRINT " DISTANCE = ";MI;" MI
     LES": PRINT
800  INPUT " PEAK HEIGHT COUNTS ?
      ";PH$
810  IF PH$ = "Q" OR PH$ = "R" THEN
      PRINT "**": GOTO 280
820 PH =  VAL (PH$)
825  PRINT "  PEAK HEIGHT COUNTS
     = ";PH
840 AMT = 0
842  FOR L = 1 TO NS
844 AMT = AMT + AS(L) * PH ^ (L -
     1)
846  NEXT L
850  PRINT " CONCENTRATION = "; INT
     (AMT * 100 + .5) / 100;" UG/
     ML": PRINT
860 FE = (.004046 * AMT * VB * VM
     ) / (VS * MI)
880 FT = (.004046 * AMT * VB * VM
     ) / VS
900  PRINT " CH2O EMISS = "; INT
     (FE * 100 + .5) / 100;" MGM/
     MI": PRINT
920  PRINT "  TOTAL CH2O = "; INT
     (FT * 100 + .5) / 100;" MGM"
     : PRINT
930  INPUT "ID FOR THIS VIAL? ";I
     N$
940  INPUT "HIT RETURN TO CONTINU
     E";IN$
950  GOTO 280
960  END
```

Fig. 8 (cont'd)

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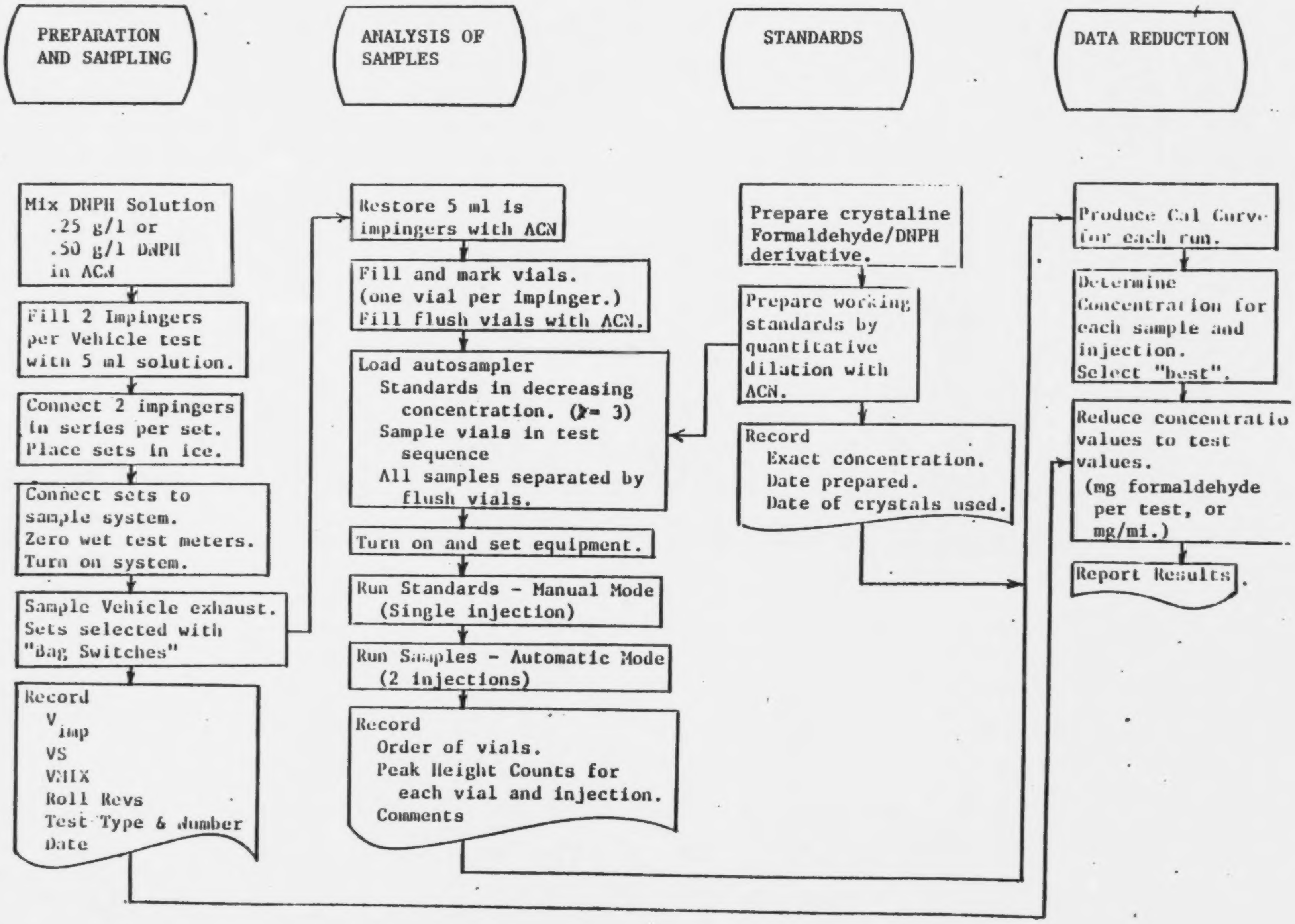
PREPARATION AND SAMPLING
ANALYSIS OF SAMPLES
STANDARDS
DATA REDUCTION
Mix DNPH Solution .25 g/l or .50 g/l DNPH in ACN
Fill 2 Impingers per Vehicle test with 5 ml solution.
Connect 2 impingers in series per set. Place sets in ice.
Connect sets to sample system. Zero wet test meters. Turn on system.
Sample Vehicle exhaust. Sets selected with "Bag Switches"
Record V imp VS VMIX Roll Revs Test Type & Number Date
Restore 5 ml is impingers with ACN
Fill and mark vials. (one vial per impinger.) Fill flush vials with ACN.
Load autosampler Standards in decreasing concentration. (≥ 3) Sample vials in test sequence All samples separated by flush vials.
Turn on and set equipment.
Run Standards - Manual Mode (Single injection)
Run Samples - Automatic Mode (2 injections)
Record Order of vials. Peak Height Counts for each vial and injection. Comments
Prepare crystaline Formaldehyde/DNPH derivative.
Prepare working standards by quantitative dilation with ACN.
Record Exact concentration. Date prepared. Date of crystals used.
Produce Cal Curve for each run.
Determine Concentration for each sample and injection. Select "best".
Reduce concentratio values to test values. (mg formaldehyde per test, or mg/mi.)
Report Results

Procedures for 2,4-Dinitrophenylhydrazone Aldehyde-Ketone Air Analysis

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Mail Drop 84, RTP, NC 27711

6/30/82

I. Reagents:

A. 2,4-Dinitrophenylhydrazine (DNPH) - Commercially available DNPH is recrystallized 2-3 times from HPLC grade acetonitrile (ACN)(Burdick and Jackson). To 50 ml of the ACN is added 3 gms of the DNPH. The solution is brought to a boil and decanted from any solid residue, allowed to cool to room temperature and then placed in an ice bath. The crystals are isolated by suction filtration with a minimum of atmospheric exposure to prevent the introduction of contaminants.

B. Sampling Solutions:

1. Ambient sampling (low ppb levels): In a 1.0 l volumetric flask 0.25 g of purified DNPH is dissolved in 1.0 l of HPLC grade ACN. To the resulting solution is added 0.2 ml of concentrated H_2SO_4.

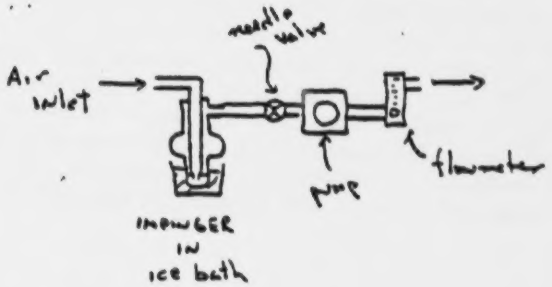
2. Laboratory sampling (ppm levels): The above concentrations are doubled.

II. Sampling Procedures:

A. Apparatus: A schematic of the apparatus is shown in Figure 1. The pump, flow controller, and flow meter all come after the impinger. The impinger is a non-frit type with the bubble tip within 3.0 mm of the bottom. The impinger should be calibrated for 2.0 and 4.0 ml of solution.

B. Ambient Samples: Without the bubbler the flow rate is adjusted for about 0.5 l/min with the needle valve. To the impinger is added 4.0 ml of the "ambient" sampling solution. The impinger is connected to the pump and the inlet lines and placed in an ice bath up to the level of the DNPH solution. The pump is then turned on and the flow readjusted to 0.5 l/min. The sampling continues for 60 minutes (30 liters). After

Figure 1. Schematic of DNPH sampling apparatus



sampling is complete the impinger is disconnected from the pump and inlet lines, caped and the solution warmed to room temperature. With the caps off the impinger the solution is made up to the 2.0 ml mark on the impinger by the addition of ACN through the inlet portion of the impinger. This serves to fix the final volume for concentration calculations latter and wash any material that collects before the sampling solution into the solution. The solution is then transferred to a teflon caped vial.

C. Laboratory sampling: The apparatus is the same except no ice bath is needed. Only 2.0 ml of DNPH laboratory sampling solution is required in the impinger and the sampling rates are from 0.1-0.5 l/minute with the total volumes from 0.25-2.0 l depending on how high the concentrations are. With the solution as constituted it would be best to keep the product of the carbonyl concentrations times the volume sampled less than 10 ppm-liters (10,000 ppb-liters) and the optimal product is 0.50 ppm-liter. For example if the carbonyl compound is at 0.5 ppm then a good sample size would be 1.0 l with the maximum being 20. liters. Another limitation arises if an accurate analysis of ketones is desired. In that case the amount of moisture introduced must be kept less than 50 microliters in the 2.0 ml of solution. The sampling volume may then be determined by taking into account the humidity of the air. After sampling the solution is made up to 2.0 ml with ACN addition (as described before) and then transferred to a teflon caped vial.

III. Analysis:

A. Standardization: Standards can be prepared in two ways.

1. Solid 2,4-Dinitrophenylhydrazones: Using standard methods (N.D. Cheronis, J.B. Entrikin, and E.M. Hodnett, Semimicro Qualitative Organic Analysis, 3rd Ed. Interscience Publishers, New York, 1965, pg. 499-501) the crystalline 2,4-dinitrophenylhydrazones of a number of the ketones and aldehydes were prepared. Weighed samples were then made up to known concentrations in ACN solution (approximately $2. \times 10^{-5}$ M) and the solutions used as standards.

2. Direct addition of the carbonyl compound to the reagent solution:

A measured volume of a liquid carbonyl compound (usually 1.0 microliter) is added to ACN (2.0 ml). An aliquot (usually 4.0 microliters) of that solution is then added to 2.0 ml of the laboratory sampling solution. Using the density of the carbonyl compound the concentration of the carbonyl compound (actually the 2,4-dinitrophenylhydrazone derivative) in the sampling solution can be calculated and the resulting solution used as a standard.

B. Analytical conditions: A Varian 5000 HPLC liquid chromatograph equipped with a built-in 254 nm ultraviolet absorbance detector connected to a Hewlett-Packard 7132A recorder, and a Variable Wavelength Spectra Physics SF 770 UV detector (set for 360 nm) connected to a Hewlett-Packard 3380S integrator were used. The analytical column was a Varian Micropak MCH-10 reversed phase 30 cm x 4 mm column. The analytical conditions are similar to those already described (K. Kuwata, M. Uebori and Y. Yamasaki, J. Chrom. Sci., 17, 264 (1979)). The HPLC conditions were 65% acetonitrile/35% water (currently the analysis is done with 64% acetonitrile/36% water to compensate for some column degration) with a flow rate of 1.5 ml/min. In Table 1 are listed the retention times and calibration factors for those common compounds for which standards have been run. The standardization factors are based on a 30 l air sample having deposited its aldehydes/ketones in 2.0 ml of the DNPH reagent solution. For smaller air samples or larger volumes of collecting solution proportional factors can be used with the standardization figures in Table 1. In Table 2 are listed the retention times and standardization factors for some terpene carbonyl compounds run with solvent programming as follows: flow 1.5 ml/min, 65% ACN/H_2O-5 minutes, 65 to 75% ACN over the next 10 minutes.

C. Analytical Procedures: The sample solutions are transferred to a heavy-walled 2.0 ml reaction vessel fitted with a teflon cap (Supelco, Inc., Bellefonte, PA) and heated 15 mins in a water bath at about 70-80°C. The solution is then injected into the HPLC via a 10 microliter sampling loop. The solution is heated for another 15 minutes and the analysis repeated until successive injections agree to within 10%. For aldehydes the development is usually complete in 10-15 minutes. For simple ketones 30 minutes usually suffices, while the dicarbonyl compounds require as much as 3 hours heating.

Using the standardization factors and retentions times the peaks can be assigned and quantified. Because the formaldehyde peak overlaps the tail of the unreacted DNPH reagent the integration obtained is often distorted by baseline triggering problems. For a reliable formaldehyde concentration it is best to draw a baseline and use the absorbance measurement to determine the concentration.

1. Ambient samples: Because all the ambient samples are likely to contain significant quantities of water (greater than 0.2 ml) the ketone responses are virtually completely suppressed by the equilibrium shown below while the

$$>C=O \; + H_2N\text{-}NHDNP \overset{H^+}{\rightleftharpoons} \; >C=NNHDNP + H_2O$$

aldehyde responses are approximately 90% of their true ambient values. This result was obtained from experiments in which water was deliberately added, as well as sampling from moist bag samples. The data on ambient samples can then be handled as all aldehyde analyses and the values obtained as being approximately 90% of the true ambient values.

For high boiling (greater than 150-200°C) ketones (in particular the terpene carbonyl compounds) it is possible to evaporate off all the solvent (ACN and water) from the sample solution by gently heating the solution in a 10 ml beaker on a hot plate (remove the solution before the last of the solvent evaporates and let it do so without further heating). Redissolving the residue in 2.0 ml (or less, if enhanced sensitivity is desired) pure ACN removes the water interference problem.

2. Laboratory samples: If the quantity of water in the sample (as determined by the humidity of the sampled air and the volume sampled) is less than about 50 microliters/2.0 ml of sampling solution there is little if any interference in the analysis of any aldehyde or ketone so far sampled. Using 2 bubblers, bag sampling, and FT-IR cross checking of concentrations indicates collection efficiences are 100% as far as it can be determined for all the varieties of compounds listed in Tables 1 and 2 from the low ppb range up to several ppm.

3. Interferences: Besides the water interference in ketone analyses, as mentioned above, there is also a potential interference of simple aromatic compounds with the HPLC analysis at 254 nm. Because the 254 UV absorbance detection is sensitive to the presence of aromaticity, any species that collects in the ACN solutions and possesses an aromatic ring can potentially interfere with the 254 nm analysis. As a practical matter only benzene, toluene, (RT 3.74 min) and the xylenes (RT 4.5 min) are likely interferences. The 254 detector is 1/25 as sensitive to the above compounds as to the DNPH derivatives so only high concentrations would interfere with the analysis of particular carbonyl compounds. The use of 360 nm detector eliminates any such potential interference.

In experiments to date no interferences of O_3 (less than 0.5 ppm), NO (less than 5 ppm), NO_2 (less than 5 ppm), and HONO (less than 5 ppm) have been observed in the 1-2 liter laboratory sampling and none have been observed with ambient sampling.

IV. General Comments: The above described method for ambient aldehyde and laboratory aldehyde/ketone analyses is simpler than the aqueous impinger method described in the literature (see above, K. Kuwata reference) since it involves no extractions (which introduce solvent contamination problems and small volume handling problems) and in addition is efficient at collecting and quantifying carbonyl compounds of six or more carbons. In tests of the aqueous impinger method it was found to give, in our hands, less than 10% of the known gas phase concentration of benzaldehyde. Also even for high concentration ("laboratory") runs on ketones, because of the presence of water (as solvent) the aqueous impinger method was not useful for ketone determinations. While the above described method has drawbacks it is a useful tool for ambient aldehyde measurements and quite useful for aldehyde/ketone measurements in experiments where the water concentrations relative to the aldehyde/ketone concentrations are in the appropriate range.

The use of 360 nm detection (instead of 254 nm) also improves the sensitivity of the analysis. The increased sensitivity could allow 15 l ambient samples or 30 min sampling time and it eliminates any potential interferences from simple aromatic compounds. For laboratory analyses this will increase the sensitivity for which there is no water interference.

For routine analyses of high concentration samples (auto exhaust for example) where carbonyl compounds may be 1-10 ppm range it should be possible to use 10-20 ml of the DNPH/ACN sampling solution ("laboratory") and collect 1-2 liters of exhaust over some convenient time (30 minutes). The resultant DNPH derivative concentrations should be ample and the water interference minimal (assuming the water is less than about 250 torr).

Care must be taken in the sampling to not unduly obstruct the flow of air into the sampling solution. It has been observed that significant decreases in the aldehyde/ketone concentrations (when in the ppb range) are observed if the gas sample passes through a simple 1 micro teflon filter.

Table 1. Retention Times and Calibration Factors for Simple Aldehyde/Ketone 2,4-Dinitrophenylhydrazones

Compound (DNPH derivative)	Retention Time (Mins) 254 nm	Absorption Cal. (ppb/Abs. unit, x 10^{-3}) 254 nm	Integration (counts/ppb) 254 nm	Integration** (counts/ppb) 360 nm
2,4-DNPH	2.47	—	—	—
Formaldehyde	3.22	2.92	1358	5437
Acetaldehyde	3.77	3.60	1313	5396
Propionaldehyde	4.51	4.91	1128	4726
Acetone	4.46	4.54	1224	5033
i-butyraldehyde	5.40	4.84	—	6327
methyl vinyl ketone	5.15	4.74	1540	—
crotonaldehyde	5.20	4.00	1819	5958
methacrolein	5.29	4.17	1651	6393
methyl ethyl ketone	5.70	5.50	1248	5138
cyclopentanone	5.75	6.3	1287	—
glyoxal	5.98	4.40	2066*	3502*
benzaldehyde	6.45	5.94	1433	4929
cyclohexanone	6.88	6.20	1426	—
o-tolualdehyde	7.51	7.76	1417	4331
methylglyoxal	8.25	5.50	2066*	3502*
hexanal	8.72	9.47	1228	5357
biacetyl	11.75	9.00	2066	3502

* Biacetyl was used as a reference to standardize these compounds which come as aqueous solutions.

** The retention times on the 360 nm detector are 0.1-0.3 minutes longer than the 254 detector since the 360 detector is "downstream" from the 254 detector.

Table 2. Retention Times and Calibration Factors for Terpene Carbonyl Compound with Solvent Programming

Compound (DNPH derivative)	Retention Time (mins) 254 nm	Absorbance Cal. (ppb/Abs, X 10^{-3}) 254 nm	Integration (counts/ppb) 254 nm	Integration (counts/ppb) 360 nm
c-pinonic acid	4.02	4.18	1478	5114
c-pinonaldehyde (mono DNPH)	5.54	—	—	—
nopinone	10.0	9.85	1012	3766
c-pinonaldehyde	13.60	5.42	1717	8629

APPENDIX 3

Fuel Analysis

Appendix 3

Analysis of One Batch of Test Fuel

The following analysis was performed by Southwest Research Institute in November 1982 and were reported to EPA in May 1983:

Test	Results
Heat of Combustion (ASTM D-240)	
Gross	10,292 Btu/lb
Net	9,143 Btu/lb
Water Content by Karl Fischer Titration (ASTM D-1744) wt. %	0.055%
API Gravity (ASTM D-287)	46.9° @ 60°F
Density (ASTM D-287)	0.7928 @ 15°C
Flash Point (ASTM D-93)	71.9°F
Acid Number (ASTM D-664) equiv. mg KOH/g sample	0.00
Lead by A.A. (ASTM D-3237)	3 ppm
Sulfur by Dohrmann Microcoulometer	N.D. (<0.001%)
Phosphorous by A.A.	1.7 ppm
Higher Alcohols by G.C.	N.D. (<0.1% ea.)

N.D. means none detected

APPENDIX 4

Individual Test Data

Emissions Data Generated over the FTP Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-5Pt:Rh(40)			**(STOCK)**	**0% O2**									
814210	0	STOCK	6-23-82	2605.0	20.16	14.1591	0.1902	0.7539	289.14	N/A	N/A	N/A	0.169
814211	0	STOCK	6-24-82	2624.0	17.43	14.1227	0.1356	0.6957	289.86	N/A	N/A	N/A	0.142
814212	0	STOCK	6-29-82	2652.4	17.18	14.1052	0.1511	0.9001	290.40	0.5941	N/A	N/A	0.208
814597	0	STOCK	7-08-82	2908.0	N/A	13.9216	0.1429	0.8150	294.50	0.5458	0.1398	.0031	N/A
814678	0	STOCK	7-09-82	2911.0	N/A	14.0618	0.1494	0.8410	290.96	0.5304	0.1465	.0029	N/A
4x6-5Pt:Rh(40)			**(STOCK)**	**3% O2**									
815125	3	STOCK	7-30-82	2987.0	15.37	13.7517	0.1431	0.6034	297.79	1.9496	0.1360	.0071	0.587
4x6-5Pt:Rh(40)			**(STOCK)**	**0% O2**									
815163+	0	STOCK	8-03-82	3006.0	27.14	14.0897	0.2623	0.8772	290.13	1.7836	0.2544	.0079	0.488
815208	0	STOCK	8-04-82	3018.0	26.26	14.7251	0.1587	0.6974	278.49	1.6792	N/A	N/A	0.303
NO CATALYST				**0% O2**									
815236+	0	NONE	8-10-82	3056.0	353.60	13.6099	1.0205	8.4539	285.83	2.1591	N/A	N/A	1.975
815238	0	NONE	8-11-82	3105.0	322.90	13.8083	0.8504	7.3019	284.24	2.1713	0.8498	.0006	1.783
815240	0	NONE	8-12-82	3144.4	313.8	13.6639	0.8728	7.3545	287.35	2.1717	0.8722	.0006	2.224
NO CATALYST				**3% O2**									
815248	3	NONE	8-18-82	3257.0	259.1	13.9984	0.7895	7.3910	280.21	2.0979	0.7885	.0010	2.135
815250	3	NONE	8-20-82	3286.0	281.3	13.9026	0.8525	7.2786	282.32	2.0922	0.8515	.0010	2.018
815254	3	NONE	8-24-82	3356.7	252.6	14.0144	0.7984	7.1572	280.38	2.1688	0.7984	.0000	2.093
NO CATALYST				**5% O2**									
815260	5	NONE	8-27-82	3453.7	185.0	13.9566	0.8024	7.2936	280.74	2.0884	N/A	N/A	N/A
815262	5	NONE	9-08-82	3492.0	189.1	13.8715	0.7675	7.2400	283.12	2.1144	N/A	N/A	2.413
815264	5	NONE	9-09-82	3541.7	197.8	13.4639	0.8304	7.7379	291.15	2.1911	N/A	N/A	2.442
4x6-12Pt:Rh(40)			**(#1)**	**0% O2**									
815272	0	(#1)	9-15-82	3682.1	8.54	14.0052	0.1005	0.4165	293.47	0.7000	N/A	N/A	0.304
815990	0	(#1)	9-17-82	3768.1	13.18	13.8863	0.1095	0.7285	295.34	0.6666	0.1042	.0053	N/A
815992	0	(#1)	9-21-82	3807.0	13.15	14.0113	0.1222	0.9340	292.29	0.4967	0.1159	.0063	0.353
4x6-12Pt:Rh(40)			**(#1)**	**3% O2**									
815995	3	(#1)	9-24-82	3861.9	17.53	14.5564	0.1131	0.3132	282.42	1.8790	0.1062	.0069	0.313
815997	3	(#1)	9-28-82	3901.5	12.88	13.6245	0.1281	0.5030	300.62	2.0981	0.1227	.0054	0.316
815999	3	(#1)	9-29-82	3940.0	16.36	13.8666	0.1149	0.3466	296.16	2.0414	0.1094	.0055	0.291
4x6-12Pt:Rh(40)			**(#1)**	**5% O2**									
816003	5	(#1)	9-30-82	4003.5	18.94	13.7625	0.1280	0.4819	297.66	2.1175	0.1228	.0052	0.269
816006	5	(#1)	10-05-82	4105.0	20.9	13.8167	0.1229	0.3778	296.85	N/A	0.1179	.0050	0.318
816011	5	(#1)	10-06-82	4124.0	22.1	14.1075	0.1082	0.3230	290.77	N/A	0.1035	.0047	0.306
816014	5	(#1)	10-07-82	4183.4	22.0	13.9527	0.1383	0.4144	293.52	2.0731	0.1315	.0068	0.375

+ Indicates a qustionable test which has been omitted from the analyses.

Emissions Data Generated over the FTP Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				**0% O2**									
816020	0	NONE	10-13-82	4280.0	207.9	14.0862	0.8084	7.464	277.84	2.1813	0.8029	.0055	2.247
816022	0	NONE	10-14-82	4319.0	198.3	14.0943	0.7848	7.3961	277.63	2.2062	0.7804	.0044	2.453
NO CATALYST				**5% O2**									
816026	5	NONE	10-15-82	4373.7	205.0	13.9498	0.8364	7.9505	280.11	2.0682	0.8315	.0049	2.530
6xRTO-12Pt:Rh(40) (#2)				**0% O2**									
816564	0	(#2)	10-20-82	4464.0	9.9	14.0781	0.1117	0.7039	291.36	0.7672	N/A	N/A	N/A
816566	0	(#2)	10-29-82	4548.0	13.0	13.8257	0.1494	0.8403	296.29	0.7553	0.1444	.0050	0.820
6xRTO-12Pt:Rh(40) (#2)				**3% O2**									
816568	3	(#2)	11-02-82	4589.6	13.35	13.6716	0.1303	0.4661	299.66	2.0682	0.1262	.0041	N/A
816572	3	(#2)	11-03-82	4645.3	14.87	13.8274	0.1199	0.2350	296.99	2.0242	0.1153	.0046	N/A
816574	3	(#2)	11-04-82	4684.8	15.14	13.7135	0.1349	0.5085	298.58	2.0442	0.1299	.0050	N/A
6xRTO-12Pt:Rh(40) (#2)				**5% O2**									
816576	5	(#2)	11-05-82	4731.3	20.81	13.7635	0.1313	0.4592	298.39	2.0939	0.1262	.0051	N/A
816580+	5	(#2)	11-18-82	4808.0	23.96	12.3230	0.1359	0.4268	333.39	1.0019	0.1290	.0069	0.286
816583+	5	(#2)	11-19-82	4850.0	18.56	12.3214	0.1096	0.5138	333.07	1.0095	0.1015	.0081	0.154
816586+	5	(#2)	11-24-82	4917.3	22.49	12.5241	0.1049	0.2558	328.10	1.0410	0.0962	.0087	N/A
NO CATALYST				**0% O2**									
816588+	0	NONE	11-30-82	4956.6	192.55	12.5239	0.6484	7.4431	315.09	1.1407	0.6420	.0064	N/A
816589+	0	NONE	12-01-82	4975.0	178.57	12.5321	0.6346	7.3333	314.96	1.1683	0.6288	.0058	1.725
816593+	0	NONE	12-02-82	5040.0	202.73	12.7421	0.6111	7.7473	308.77	1.0961	0.6051	.0060	1.481
816595+	0	NONE	12-03-82	5081.0	197.24	12.7486	0.6443	7.5822	308.98	1.1340	0.6390	.0053	1.940
816597	0	NONE	12-07-82	5123.5	N/A	13.3990	0.8553	7.3561	292.91	2.1846	N/A	N/A	N/A
816600	0	NONE	12-08-82	5156.0	209.55	14.0500	0.9118	7.7299	278.11	2.0816	0.9063	.0055	N/A
4x6-3Pt:2Pd(20) (#3)				**0% O2**									
816604	0	(#3)	12-09-82	5207.0	29.52	13.6483	0.1462	1.3991	299.37	0.8703	0.1424	.0038	N/A
816606	0	(#3)	12-10-82	5246.0	36.39	13.8791	0.1607	1.3575	294.13	0.8393	0.1549	.0058	N/A
816608	0	(#3)	12-14-82	5285.0	N/A	13.8121	0.1564	1.6463	294.90	0.8494	N/A	N/A	N/A
4x6-3Pt:2Pd(20) (#3)				**3% O2**									
816617	3	(#3)	12-17-82	5416.0	N/A	13.3648	0.1566	0.3553	307.12	2.0855	0.1507	.0059	0.212
816621	3	(#3)	12-21-82	5466.7	72.94	13.4959	0.1636	0.3453	304.36	2.0517	0.1562	.0074	0.340
4x6-3Pt:2Pd(20) (#3)				**5% O2**									
817462	5	(#3)	12-22-82	5520.0	117.4	13.5379	0.1810	0.3499	302.97	2.0929	N/A	N/A	0.296
817464	5	(#3)	12-23-82	5559.0	117.3	13.4848	0.1994	0.4406	303.84	1.9743	0.1930	.0064	0.423
NO CATALYST				**0% O2**									
817470	0	NONE	1-05-83	5627.5	131.60	13.5115	0.8626	8.2650	289.01	2.1324	N/A	N/A	N/A

Emissions Data Generated over the FTP Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Pd(40) (#4) 0% O2													
817476	0	(#4)	1-07-83	5695.0	39.19	13.4461	0.1902	2.2857	301.62	0.7548	N/A	N/A	0.352
817478	0	(#4)	1-11-83	5734.8	38.55	13.5521	0.1636	2.0877	299.86	0.7479	0.1577	.0059	0.339
817480	0	(#4)	1-12-83	5773.0	46.90	13.4118	0.1533	1.5873	304.39	0.7261	0.1492	.0041	N/A
4x6-Pd(40) (#4) 3% O2													
817484	3	(#4)	1-13-83	5834.0	76.65	13.4950	0.1514	0.3936	304.12	1.9570	0.1468	.0046	N/A
817488	3	(#4)	1-18-83	5931.0	59.33	13.3667	0.1384	0.3657	307.43	2.0082	0.1340	.0044	N/A
4x6-Pd(40) (#4) 5% O2													
817495	5	(#4)	1-19-83	5985.0	111.29	13.2414	0.1510	0.2864	310.47	2.0927	0.1453	.0057	N/A
817499	5	(#4)	1-20-82	6035.4	172.67	13.2268	0.1754	0.4578	309.96	2.1090	0.1701	.0053	N/A
817919	5	(#4)	1-25-83	6053.9	141.64	13.3241	0.1531	0.3253	308.29	1.9532	0.1482	.0049	N/A
NO CATALYST 0% O2													
817922	0	NONE	1-27-83	6104.3	325.72	N/A	0.9126	8.4891	N/A	2.0563	0.9081	.0045	N/A
4x6-Pd+Base Metal(35) (#5) 0% O2													
817925+	0	(#5)	1-28-83	6135.3	N/A	N/A	0.2686	3.4711	N/A	1.9117	0.2645	.0041	N/A
817929+	0	(#5)	2-01-83	6188.7	N/A	N/A	0.3128	3.7811	N/A	2.0131	0.3083	.0045	N/A
4x6-Pd+Base Metal(35) (#5) 3% O2													
817933+	3	(#5)	2-02-83	6246.0	N/A	13.6595	0.2700	1.6259	298.38	1.9024	0.2656	.0044	N/A
4x6-Pd+Base Metal(35) (#5) ??% O2 (SUPPOSE TO HAVE BEEN 3%)													
817937+	0	(#5)	2-03-83	6302.0	N/A	13.6756	0.2951	1.9913	296.89	1.9255	0.2907	.0044	N/A
4x6-Pd+Base Metal(35) (#5) 3% O2													
817938+	3	(#5)	2-04-83	6331.4	N/A	13.7643	0.2835	2.0466	294.88	2.0207	0.2782	.0053	N/A
4x6-Pd+Base Metal(35) (#5) 0% O2													
817939	0	(#5)	2-09-83	6393.5	118.46	14.1410	0.2767	2.7232	285.53	1.9502	0.2696	.0071	N/A
817943	0	(#5)	2-10-83	6444.8	119.24	N/A	0.2770	2.9788	N/A	1.9934	0.2704	.0066	N/A
4x6-Pd+Base Metal(35) (#5) 3% O2													
817947	3	(#5)	2-11-83	6501.3	117.52	N/A	0.2749	1.9386	N/A	2.0035	0.2668	.0081	N/A
817951	3	(#5)	2-15-83	6555.5	141.23	13.8953	0.2811	2.1652	291.97	1.8986	0.2744	.0067	N/A
4x6-Pd+Base Metal(35) (#5) 5% O2													
817955	5	(#5)	2-16-83	6611.4	253.12	13.7489	0.3709	3.3620	293.02	1.9466	0.3622	.0087	N/A
817957	5	(#5)	2-17-83	6651.0	280.90	13.9140	0.3584	3.6692	289.27	1.9139	0.3520	.0064	N/A
818396	5	(#5)	2-18-83	6706.0	304.58	13.8929	0.3706	3.9338	289.16	1.9529	0.3640	.0066	N/A

Emissions Data Generated over the FTP Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				0% O2									
818400	0	NONE	2-22-83	6759.8	232.07	13.8246	0.9258	7.5592	283.27	2.0131	0.9179	.0079	N/A
818402	0	NONE	2-23-83	6798.0	265.72	13.8391	0.9710	7.2660	282.68	1.9658	0.9646	.0064	N/A
4x6-Cu Mesh (#6)				0% O2									
818404	0	(#6)	2-24-83	6838.0	268.82	13.7239	0.9053	7.7205	285.38	1.8650	0.8970	.0083	N/A
818408	0	(#6)	2-25-83	6895.0	315.03	13.6627	0.9007	7.3105	286.85	1.9046	0.8932	.0075	N/A
4x6-Cu Mesh (#6)				3% O2									
818412	3	(#6)	3-01-83	6961.0	312.47	13.4330	0.9201	7.3714	291.51	1.8147	0.9138	.0063	N/A
818416	3	(#6)	3-02-83	7016.3	332.15	13.4489	0.8846	7.2143	291.94	1.8197	0.8784	.0062	N/A
4x6-Cu Mesh (#6)				5% O2									
818648	5	(#6)	3-03-83	7073.1	303.13	13.5060	0.9055	6.9835	291.39	1.8135	0.8977	.0078	N/A
818652	5	(#6)	3-04-83	7125.0	324.61	13.4351	0.8324	6.8828	293.39	1.8320	0.8256	.0068	N/A
NO CATALYST				0% O2									
818656	0	NONE	3-08-83	7178.3	219.54	14.0177	1.0565	7.2349	278.54	1.9660	1.0481	.0084	N/A
818658	0	NONE	3-09-83	7217.3	230.35	14.0640	1.0425	7.2773	277.80	1.9656	1.0342	.0083	N/A
4x6-Pd(20) (#7)				0% O2									
818660	0	(#7)	3-10-83	7256.7	35.35	13.9155	0.1668	1.4919	292.75	0.6251	0.1621	.0047	N/A
818664	0	(#7)	3-11-83	7310.0	39.11	13.8335	0.1869	1.9312	294.40	0.6709	0.1781	.0088	N/A
818668	0	(#7)	3-15-83	7365.0	48.63	13.6820	0.2008	2.0945	296.69	0.7029	0.1934	.0074	N/A
4x6-Pd(20) (#7)				3% O2									
818725	3	(#7)	3-16-83	7420.0	99.72	13.9038	0.1598	0.3941	294.71	1.8527	0.1526	.0072	N/A
818729	3	(#7)	3-17-83	7472.2	88.67	13.7657	0.1459	0.4040	297.97	1.9380	0.1403	.0056	N/A
4x6-Pd(20) (#7)				5% O2									
818733+	5	(#7)	3-18-83	7530.0	115.28	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
818737	5	(#7)	3-22-83	7579.7	102.16	13.7716	0.1400	0.3263	298.28	1.9085	N/A	N/A	N/A
818741	5	(#7)	3-23-83	7632.1	105.82	13.6385	0.1288	0.2993	301.38	1.9065	N/A	N/A	N/A
NO CATALYST				0% O2									
818978	0	NONE	3-24-83	7682.0	211.00	14.0143	1.0000	7.3888	278.73	2.0565	N/A	N/A	N/A
818980	0	NONE	3-25-83	7722.0	218.56	14.1724	1.0123	7.1922	276.11	2.0132	N/A	N/A	N/A
NO CATALYST				3% O2									
818982	3	NONE	3-29-83	7765.0	222.72	14.0677	1.0679	7.1849	278.22	2.0030	N/A	N/A	N/A
818984	3	NONE	3-30-83	7804.0	219.32	13.6865	1.0762	7.2631	286.13	2.1006	N/A	N/A	N/A

Emissions Data Generated over the FTP Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				5% O2									
818986	5	NONE	3-31-83	7845.0	233.69	13.9007	1.0617	7.5204	280.93	1.9903	N/A	N/A	N/A
818988	5	NONE	4-05-83	7892.0	231.03	13.8115	1.1244	7.3404	283.13	2.0798	1.1164	.0080	N/A
4x6-Ag(150) (#8)				0% O2									
818990	0	(#8)	4-07-83	7940.0	41.80	14.0376	0.4460	6.2919	281.64	2.0192	0.4399	.0061	N/A
818994	0	(#8)	4-08-83	7991.0	58.46	13.8416	0.6113	6.6857	284.78	2.0506	0.6032	.0081	N/A
819235	0	(#8)	4-13-83	8074.0	66.04	13.7650	0.5472	6.5997	286.98	2.0083	0.5400	.0072	N/A
819237	0	(#8)	4-15-83	8110.0	70.97	13.7698	0.5538	6.5237	287.39	2.0347	0.5468	.0070	N/A
4x6-Ag(150) (#8)				3% O2									
819238	3	(#8)	4-19-83	8137.0	50.18	13.6506	0.4532	5.8430	291.45	1.9848	0.4450	.0082	N/A
819240	3	(#8)	4-20-83	8185.0	34.67	13.6009	0.3527	5.4735	292.53	2.0052	N/A	N/A	N/A
819245	3	(#8)	4-22-83	8275.0	71.04	13.8767	0.4781	6.4773	284.98	1.9775	0.4713	.0068	N/A
4x6-Ag(150) (#8)				5% O2									
819249	5	(#8)	4-27-83	8356.0	73.80	13.7857	0.5418	6.9620	285.50	1.8919	0.5346	.0072	N/A
819252	5	(#8)	4-29-83	8424.0	85.00	13.5377	0.5916	7.1622	291.46	2.0046	0.5844	.0072	N/A
819262	5	(#8)	5-05-83	8514.0	102.05	13.9177	0.6247	6.8994	283.19	1.9650	0.6167	.0080	N/A
NO CATALYST				0% O2									
819263	0	NONE	5-06-83	8533.0	183.93	14.0964	1.0095	6.9197	277.77	2.0113	1.0025	.0070	N/A
819265	0	NONE	5-10-83	8572.0	173.89	13.9068	1.0365	7.4922	281.36	2.0102	1.0308	.0057	N/A
819267	0	NONE	5-19-83	8652.0	111.73	14.5575	1.0070	7.4005	267.77	1.8276	0.9994	.0076	N/A
819269	0	NONE	5-20-83	8691.0	219.76	14.5330	1.0294	7.6570	268.30	1.8547	1.0222	.0072	N/A
819271	0	NONE	5-24-83	8730.0	219.46	14.3981	1.0091	7.4763	270.78	1.7638	1.0013	.0078	N/A
819277	0	NONE	5-25-83	8782.0	232.09	13.9331	1.0174	7.8090	280.28	1.9890	1.0094	.0080	N/A
820322	0	NONE	5-26-83	8833.0	234.06	14.0009	1.0001	7.5719	279.44	2.0091	0.9928	.0073	N/A
820385	0	NONE	7-08-83	9043.0	285.75	14.5927	1.1186	6.7436	268.15	1.8562	1.1112	.0074	N/A
NO CATALYST				0% O2 (Resumed)									
840104	0	NONE	10-14-83	9157.0	204.93	14.7720	1.0215	6.0271	266.15	1.8697	N/A	N/A	N/A
840106	0	NONE	10-19-83	9205.0	264.70	14.9826	1.1496	6.4610	260.85	1.8701	1.1399	.0097	N/A
840108	0	NONE	10-20-83	9243.8	242.82	14.6406	1.1348	6.1220	268.14	1.9198	1.1270	.0078	N/A
840109	0	NONE	10-21-83	9259.0	246.43	14.5418	1.1421	6.0508	269.91	1.9525	1.1348	.0073	N/A
4x6-Cu - Acid Dipped (#9)				0% O2									
840111	0	(#9)	10-27-83	9310.0	453.85	14.5178	0.7229	5.9238	272.16	1.7452	0.7155	.0074	N/A
840113	0	(#9)	10-28-83	9349.0	405.88	15.5361	0.7014	5.5893	254.25	1.6340	0.6936	.0078	N/A
840114	0	(#9)	11-01-83	9376.0	420.54	14.7515	0.8827	5.9179	267.17	1.7974	0.8743	.0084	N/A
840116	0	(#9)	11-02-83	9414.0	408.73	14.7054	0.8293	5.9531	268.44	1.8118	0.8210	.0083	N/A
840118	0	(#9)	11-03-83	9454.0	439.87	14.6479	0.8354	6.0003	268.67	1.7926	0.8275	.0079	N/A
4x6-Cu - Acid Dipped (#9)				3% O2									
840120	3	(#9)	11-08-83	9513.0	395.50	13.6820	0.9184	6.3669	287.54	2.0106	0.9105	.0079	N/A
840126	3	(#9)	11-09-83	9566.0	423.75	13.7290	0.9332	6.3230	287.12	1.9970	0.9233	.0099	N/A
840132	3	(#9)	11-10-83	9618.0	562.94	13.8709	0.9457	6.2508	284.44	1.9624	0.9366	.0091	N/A

Emissions Data Generated over the FTP Driving Cycle (Continued)

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				**0% 02**									
840138	0	NONE	2-14-84	9742.3	N/A	15.4239	1.4519	9.1202	247.86	1.5026	1.4475	.0044	N/A
840143	0	NONE	2-15-84	9795.6	N/A	15.8739	1.1249	7.5095	243.95	1.5859	1.1234	.0015	N/A
840148	0	NONE	3-08-84	9848.5	N/A	15.4535	1.2477	8.5745	248.95	1.5364	1.2421	.0056	N/A
4x6-Pd+Base Metal(5) (#10) 0% 02													
840153	0	(#10)	3-09-84	9902.0	N/A	15.2880	0.1933	1.0763	267.24	0.8175	0.1855	.0078	N/A
840155	0	(#10)	3-13-84	9941.7	N/A	15.3915	0.1932	1.1956	264.65	0.8275	0.1913	.0019	N/A
840157	0	(#10)	4-04-84	9988.3	N/A	15.2616	0.1963	1.3666	266.51	0.8452	0.1900	.0063	N/A
4x6-Pd+Base Metal(5) (#10) 3% 02													
840159	3	(#10)	4-05-84	10032.6	N/A	14.5697	0.1778	0.6505	280.56	1.7603	0.1697	.0081	N/A
840161	3	(#10)	4-06-84	10074.8	N/A	14.5316	0.1756	0.4902	281.99	1.7665	0.1684	.0072	N/A
843392	3	(#10)	4-10-84	10116.5	N/A	14.2750	0.1951	0.5066	287.14	1.8869	0.1871	.0080	N/A
4x6-Pd+Base Metal(5) (#10) 5% 02													
843394	5	(#10)	4-11-84	10161.4	N/A	14.3065	0.2159	0.6965	286.06	1.8386	0.2068	.0091	N/A

Emissions Data Generated over the HWY Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-5Pt:Rh(40)			(STOCK)	**0% O2**									
814213	0	STOCK	6-29-82	2674.0	0.7	18.1264	0.0040	0.0807	227.30	0.1193	0.0007	.0033	0.003
814216	0	STOCK	6-30-82	2710.0	0.00	17.9689	0.0008	0.0834	229.10	0.1332	0.0012	-.0004	0.007
814219	0	STOCK	7-01-82	2766.9	0.1	18.0390	0.0006	0.1507	227.83	0.0465	N/A	N/A	0.002
814222	0	STOCK	7-02-82	2823.1	0.1	18.2010	0.0012	0.1274	225.55	0.0683	0.0008	.0004	0.003
NO CATALYST				**0% O2**									
815237	0	NONE	8-10-82	3067.0	134.25	16.6392	0.4307	6.4057	236.38	3.0085	N/A	N/A	0.179
815239	0	NONE	8-11-82	3116.3	189.6	16.7268	0.4220	6.2377	235.01	3.0248	0.4215	.0005	0.831
815241	0	NONE	8-12-82	3155.4	193.0	17.0821	0.4139	6.1797	229.76	2.9135	0.4133	.0006	0.918
NO CATALYST				**3% O2**									
815249	3	NONE	8-18-82	3268.0	172.2	17.3098	0.3801	6.1442	226.71	2.9541	0.3798	.0003	0.888
815251	3	NONE	8-20-82	3307.0	171.7	17.4993	0.3623	5.8090	225.28	2.8343	0.3618	.0005	0.946
815255	3	NONE	8-24-82	3376.0	179.6	17.2819	0.3637	5.7837	228.35	2.8127	0.3637	.0000	0.948
NO CATALYST				**5% O2**									
815261	5	NONE	8-27-82	3475.0	140.6	17.4107	0.3549	5.9499	225.62	2.9286	N/A	N/A	N/A
815263	5	NONE	9-08-82	3524.0	139.5	17.4662	0.3343	6.1466	225.10	2.7814	N/A	N/A	0.883
815265	5	NONE	9-09-82	3572.0	139.7	17.0300	0.3514	6.1377	230.98	2.9443	N/A	N/A	0.795
4x6-12Pt:Rh(40)			(#1)	**0% O2**									
815273	0	(#1)	9-15-82	3702.0	1.0	17.4390	0.0041	0.0540	235.59	0.6182	0.0038	.0003	0.012
815274	0	(#1)	9-16-82	3736.0	0.3	17.2951	0.0030	0.0269	238.21	0.6329	0.0027	.0003	0.006
815991	0	(#1)	9-17-82	3778.0	0.3	17.2193	0.0030	0.0640	239.04	0.5804	0.0030	.0000	N/A
4x6-12Pt:Rh(40)			(#1)	**3% O2**									
815996	3	(#1)	9-24-82	3872.9	1.1	18.7124	0.0081	0.0	219.54	2.4257	0.0059	.0022	0.004
815998	3	(#1)	9-28-82	3912.5	1.0	17.0807	0.0094	0.0051	240.80	2.8921	0.0069	.0025	0.005
816000	3	(#1)	9-29-82	3951.0	1.6	17.4427	0.0084	0.0085	235.91	2.8837	0.0068	.0016	0.004
4x6-12Pt:Rh(40)			(#1)	**5% O2**									
816004	5	(#1)	9-30-82	4020.5	2.2	17.2234	0.0097	0.0070	239.10	2.9207	0.0071	.0026	0.006
816012	5	(#1)	10-06-82	4134.0	1.9	17.4434	0.0098	0.0017	236.04	N/A	0.0070	.0028	0.005
816013	5	(#1)	10-06-82	4156.0	1.9	17.3703	0.0077	0.0	236.66	2.7212	0.0048	.0029	0.009
816015	5	(#1)	10-07-82	4213.5	1.7	17.5174	0.0114	0.0	234.86	2.7040	0.0080	.0034	0.004
NO CATALYST				**0% O2**									
816021	0	NONE	10-13-82	4300.0	164.6	17.3073	0.3859	6.1530	226.67	2.9362	0.3835	.0024	0.632
816023	0	NONE	10-14-82	4330.0	167.0	17.3474	0.3839	6.4405	226.24	2.9066	0.3813	.0026	0.904
NO CATALYST				**5% O2**									
816027	5	NONE	10-15-82	4384.0	147.0	17.5255	0.3927	6.1640	224.12	2.8608	0.3900	.0027	0.937

Emissions Data Generated over the HWY Driving Cycle (Continued)

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
6xRTO-12Pt:Rh(40) (#2)				0% 02									
816028	0	(#2)	10-19-82	4424.0	1.6	18.0459	0.0129	0.0671	228.40	0.4786	0.0126	.0003	0.065
816565	0	(#2)	10-20-82	4484.0	1.1	17.9699	0.0070	0.0633	229.38	0.4752	N/A	N/A	N/A
816567	0	(#2)	10-29-82	4570.2	0.8	17.1471	0.0050	0.0572	239.52	0.6975	0.0046	.0004	0.004
6xRTO-12Pt:Rh(40) (#2)				3% 02									
816569	3	(#2)	11-02-82	4611.0	1.6	17.2948	0.0093	0.0234	237.75	2.8525	0.0080	.0013	0.010
816573	3	(#2)	11-03-82	4666.6	2.2	17.4416	0.0082	0.0241	236.36	2.8026	0.0072	.0010	0.009
816575	3	(#2)	11-04-82	4706.0	2.3	17.3666	0.0087	0.0276	237.38	2.8602	0.0073	.0014	0.023
6xRTO-12Pt:Rh(40) (#2)				5% 02									
816577	5	(#2)	11-05-82	4753.0	2.2	17.3664	0.0098	0.0282	237.17	2.7982	0.0083	.0015	0.027
816581+	5	(#2)	11-18-82	4816.0	1.4	15.4150	0.0089	0.0391	266.94	0.9135	0.0058	.0031	0.013
816584+	5	(#2)	11-19-82	4861.0	1.3	15.4733	0.007	0.041	266.10	0.9201	0.0045	.0025	0.010
816587+	5	(#2)	11-24-82	4938.6	1.2	15.7707	0.0061	0.0340	261.20	0.3223	0.0036	.0025	N/A
NO CATALYST				0% 02									
816590+	0	NONE	12-01-82	4986.0	79.6	15.3650	0.1127	6.1142	257.98	0.9980	0.1087	.0040	0.280
816591+	0	NONE	12-01-82	4998.0	86.4	15.4222	0.1099	6.1206	256.52	0.9859	0.1059	.0040	0.296
816594+	0	NONE	12-02-82	5061.0	95.9	15.5196	0.1183	6.3107	255.32	0.9713	0.1140	.0043	0.335
816596+	0	NONE	12-03-82	5102.0	91.1	15.3513	0.1237	6.2414	257.68	0.9981	0.1201	.0036	0.335
816601	0	NONE	12-08-82	5177.0	180.7	17.3412	0.3913	6.475	225.94	2.7854	0.3880	.0033	N/A
4x6-3Pt:2Pd(20) (#3)				0% 02									
816605	0	(#3)	12-09-82	5239.0	0.91	16.9194	0.0090	0.1985	243.41	0.6462	0.0079	.0011	N/A
816607	0	(#3)	12-10-82	5268.0	1.17	17.2005	0.0061	0.2194	239.18	0.6255	0.0052	.0009	N/A
816609	0	(#3)	12-14-82	5296.0	N/A	17.3441	0.0069	0.2312	237.26	0.6478	N/A	N/A	N/A
4x6-3Pt:2Pd(20) (#3)				3% 02									
816614	3	(#3)	12-16-82	5387.0	N/A	16.8716	0.0099	0.0006	244.19	2.7580	0.0071	.0028	N/A
816618	3	(#3)	12-17-82	5438.0	N/A	16.8030	0.0095	0.0006	244.82	2.8118	0.0060	.0035	0.011
817459	3	(#3)	12-21-82	5488.0	1.7	17.0794	0.0100	0.0174	241.17	2.7388	0.0065	.0035	0.016
4x6-3Pt:2Pd(20) (#3)				5% 02									
817463	5	(#3)	12-22-82	5541.0	3.04	17.0110	0.0100	0.0005	242.24	2.8272	0.0065	.0035	0.009
817465	5	(#3)	12-23-82	5580.0	2.93	17.0807	0.0092	0.0078	241.45	2.7420	0.0060	.0032	0.009
NO CATALYST				0% 02									
817471	0	NONE	1-05-83	5635.0	69.13	17.0739	0.4087	6.9041	229.10	2.7800	N/A	N/A	N/A
4x6-Pd(40) (#4)				0% 02									
817477	0	(#4)	1-07-83	5717.0	< 0.36	17.0440	0.0043	0.3455	241.29	0.5207	N/A	N/A	0.024
817479	0	(#4)	1-11-83	5745.0	1.10	16.9755	0.0058	0.3343	242.18	0.5736	0.0052	.0006	0.008
817481	0	(#4)	1-12-83	5795.0	0.71	16.9091	0.0064	0.2988	242.81	0.4281	0.0055	.0009	N/A

Emissions Data Generated over the HWY Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Pd(40) (#4)				**3% O2**									
817485	3	(#4)	1-13-83	5855.0	1.67	17.0101	0.0090	0.0144	241.56	2.6469	0.0072	.0018	N/A
817489	3	(#4)	1-14-83	5902.0	1.90	17.0811	0.0073	0.0086	240.64	2.6516	0.0047	.0026	N/A
4x6-Pd(40) (#4)				**5% O2**									
817492	5	(#4)	1-18-83	5955.0	2.65	17.0807	0.0086	0.0145	241.35	2.7267	0.0057	.0029	N/A
817496	5	(#4)	1-19-83	6007.0	2.80	16.9401	0.0094	0.0107	243.15	2.7164	0.0065	.0029	N/A
NO CATALYST				**0% O2**									
817921	0	NONE	1-26-83	6086.0	211.3	N/A	0.4329	7.0037	N/A	2.7261	0.4296	.0033	N/A
4x6-Pd+Base Metal(35) (#5)				**0% O2**									
817926+	0	(#5)	1-28-83	6156.0	N/A	N/A	0.0182	1.0911	N/A	1.2387	0.0152	.0030	N/A
817930+	0	(#5)	2-01-83	6210.0	N/A	N/A	0.0165	1.1313	N/A	1.5205	0.0136	.0029	N/A
4x6-Pd+Base Metal(35) (#5)				**3% O2**									
817934+	3	(#5)	2-02-83	6267.4	N/A	16.9395	0.0122	0.0118	242.57	2.5252	0.0096	.0026	N/A
4x6-Pd+Base Metal(35) (#5)				**0% O2**									
817940	0	(#5)	2-09-83	6417.0	2.64	17.5876	0.0166	1.3046	232.45	1.5459	0.0120	.0046	N/A
817944	0	(#5)	2-10-83	6466.0	3.59	N/A	0.0150	1.6607	N/A	1.7229	0.0110	.0040	N/A
4x6-Pd+Base Metal(35) (#5)				**3% O2**									
817948	3	(#5)	2-11-83	6512.4	2.76	N/A	0.0132	0.0306	N/A	2.5670	0.0093	.0039	N/A
817952	3	(#5)	2-15-83	6576.0	3.2	17.5099	0.0132	0.0608	234.96	2.6360	0.0092	.0040	N/A
4x6-Pd+Base Metal(35) (#5)				**5% O2**									
817958	5	(#5)	2-17-83	6672.0	11.48	17.5529	0.0133	0.3297	233.66	2.6455	0.0089	.0044	N/A
818397	5	(#5)	2-18-83	6727.0	17.46	17.8363	0.0146	0.5045	230.27	2.6354	0.0100	.0046	N/A
NO CATALYST				**0% O2**									
818401	0	NONE	2-22-83	6781.1	147.92	17.3571	0.4054	6.9511	225.13	2.8481	0.4007	.0047	N/A
818403	0	NONE	2-23-83	6819.0	215.12	17.5023	0.4203	6.9380	222.74	2.6737	0.4160	.0043	N/A
4x6-Cu Mesh (#6)				**0% O2**									
818405	0	(#6)	2-24-83	6859.0	136.31	17.3650	0.3463	6.9953	225.36	2.3906	0.3408	.0055	N/A
818409	0	(#6)	2-25-83	6917.0	125.11	16.6994	0.2617	6.8242	234.83	2.4293	0.2561	.0056	N/A
4x6-Cu Mesh (#6)				**3% O2**									
818413	3	(#6)	3-01-83	6987.0	137.98	17.0205	0.2053	6.5169	230.70	2.2578	0.1994	.0059	N/A
818645	3	(#6)	3-02-83	7037.5	136.34	16.9041	0.1941	6.3267	232.75	2.3029	0.1891	.0050	N/A
4x6-Cu Mesh (#6)				**5% O2**									
818649	5	(#6)	3-03-83	7094.3	127.17	16.9140	0.1690	6.2852	232.81	2.2086	0.1636	.0054	N/A
818653	5	(#6)	3-04-83	7146.2	121.33	16.5380	0.1308	6.0667	238.52	2.2044	0.1251	.0057	N/A

Emissions Data Generated over the HWY Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				**0% O2**									
818657	0	NONE	3-08-83	7199.0	169.05	17.4239	0.4782	6.8550	223.59	2.5988	0.4727	.0055	N/A
818659	0	NONE	3-09-83	7238.0	177.73	17.4909	0.4878	6.9001	223.09	2.6669	0.4826	.0052	N/A
4x6-Pd(20) (#7)				**0% O2**									
818661	0	(#7)	3-10-83	7278.0	1.99	17.2602	0.0109	0.3181	237.65	0.2972	0.0089	.0020	N/A
818665	0	(#7)	3-11-83	7331.0	1.87	17.3976	0.0083	0.3993	235.58	0.3231	0.0060	.0023	N/A
818669	0	(#7)	3-15-83	7386.0	N/A	17.1073	0.0084	0.4122	239.92	0.4224	0.0064	.0020	N/A
4x6-Pd(20) (#7)				**3% O2**									
818726	3	(#7)	3-16-83	7442.0	2.93	17.0820	0.0080	-0.0038	240.70	2.5117	0.0052	.0028	N/A
818730	3	(#7)	3-17-83	7493.0	2.44	17.0103	0.0085	0.0109	241.73	2.5744	0.0054	.0031	N/A
4x6-Pd(20) (#7)				**5% O2**									
818734	5	(#7)	3-18-83	7551.0	2.38	17.0820	0.0084	0.0038	241.03	2.5116	0.0051	.0033	N/A
818738	5	(#7)	3-22-83	7600.0	3.39	17.1532	0.0079	0.0005	240.48	2.6069	N/A	N/A	N/A
818975	5	(#7)	3-23-83	7653.0	2.93	16.8714	0.0106	0.0041	244.45	2.7254	N/A	N/A	N/A
NO CATALYST				**0% O2**									
818979	0	NONE	3-24-83	7704.0	144.90	16.9872	0.4572	6.9463	230.05	2.8408	N/A	N/A	N/A
818981	0	NONE	3-25-83	7743.0	89.26	17.2679	0.4763	6.9492	226.47	2.6875	N/A	N/A	N/A
NO CATALYST				**3% O2**									
818983	3	NONE	3-29-83	7787.0	144.92	17.5282	0.4592	6.6369	223.05	2.6645	N/A	N/A	N/A
818985	3	NONE	3-30-83	7826.0	129.94	17.0811	0.4706	6.7072	228.77	2.8010	N/A	N/A	N/A
NO CATALYST				**5% O2**									
818987	5	NONE	3-31-83	7867.0	139.15	17.2109	0.4793	6.8053	226.83	2.7454	N/A	N/A	N/A
818989	5	NONE	4-05-83	7914.0	121.86	17.1635	0.4764	6.5993	228.27	2.7699	0.4715	.0049	N/A
4x6-Ag(150) (#8)				**0% O2**									
818991	0	(#8)	4-07-83	7961.3	3.15	17.1595	0.0269	4.3635	232.73	2.7203	0.0222	.0047	N/A
818995	0	(#8)	4-08-83	8013.0	2.02	17.0239	0.0240	4.3117	235.15	2.7404	0.0195	.0045	N/A
818998	0	(#8)	4-12-83	8052.0	1.92	17.1198	0.0209	4.0922	233.77	2.7685	0.0159	.0050	N/A
4x6-Ag(150) (#8)				**3% O2**									
819239	3	(#8)	4-19-83	8158.0	2.44	17.2059	0.0228	3.3188	233.57	2.6662	0.0178	.0049	N/A
819241	3	(#8)	4-20-83	8206.0	1.77	16.9968	0.0203	3.2917	237.43	2.7236	0.0155	.0048	N/A
819242	3	(#8)	4-21-83	8240.0	1.77	17.3945	0.0166	3.5916	230.54	2.6230	0.0118	.0048	N/A
819246	3	(#8)	4-22-83	8316.7	1.45	17.5324	0.0163	3.6759	229.00	2.5562	0.0120	.0043	N/A
4x6-Ag(150) (#8)				**5% O2**									
819250	5	(#8)	4-27-83	8377.0	5.36	17.5133	0.0238	5.1001	226.55	2.5913	0.0193	.0045	N/A
819251	5	(#8)	4-28-83	8405.3	4.98	18.8888	0.0213	5.0321	210.37	2.2555	0.0162	.0051	N/A
819253	5	(#8)	4-29-83	8445.0	4.50	17.0627	0.0249	5.2253	233.08	2.6862	0.0206	.0043	N/A

Emissions Data Generated over the HWY Driving Cycle (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				**0% O2**									
819264	0	NONE	5-06-83	8554.0	111.97	17.4057	0.4343	6.4728	224.53	2.8210	0.4300	.0043	N/A
819266	0	NONE	5-10-83	8593.0	106.44	17.2540	0.4439	6.4959	227.30	2.8269	0.4395	.0044	N/A
819268	0	NONE	5-19-83	8674.0	128.16	18.8713	0.4213	6.2602	207.31	2.4394	0.4161	.0052	N/A
819270	0	NONE	5-20-83	8713.0	121.84	18.5342	0.4214	6.2423	210.72	2.5116	0.4168	.0046	N/A
819272	0	NONE	5-24-83	8752.0	130.08	18.7688	0.4218	6.3841	207.86	2.3913	0.4176	.0042	N/A
819278	0	NONE	5-25-83	8803.0	93.83	17.3708	0.4398	6.7550	225.27	2.7549	0.4350	.0048	N/A
820323	0	NONE	5-26-83	8854.0	89.63	17.3824	0.4298	6.6793	225.13	2.7873	0.4256	.0042	N/A
820375	0	NONE	7-06-83	8969.0	N/A	19.0625	0.4258	6.1342	204.93	2.2884	0.4210	.0048	N/A
820380	0	NONE	7-07-83	9013.0	171.09	18.8187	0.4166	6.0197	208.49	2.4026	0.4117	.0049	N/A
NO CATALYST				**0% O2**	**(Resumed)**								
820388	0	NONE	9-23-83	9111.0	138.78	18.6631	0.4916	5.1169	211.14	2.4762	0.4857	.0059	N/A
840105	0	NONE	10-14-83	9179.0	132.67	19.0452	0.4423	4.9532	207.20	2.5630	N/A	N/A	N/A
840107	0	NONE	10-19-83	9226.0	182.80	19.6229	0.4512	4.6974	201.30	2.4149	0.4462	.0050	N/A
840110	0	NONE	10-21-83	9280.0	148.79	18.8779	0.4798	4.8228	208.62	2.5137	0.4747	.0051	N/A
4x6-Cu - Acid Dipped (#9) 0% O2													
840112	0	(#9)	10-27-83	9331.0	N/A	18.8144	0.0205	1.7608	216.29	1.8778	0.0155	.0050	N/A
840115	0	(#9)	11-01-83	9397.0	149.90	18.9279	0.0357	3.4382	212.31	2.2875	0.0302	.0055	N/A
840117	0	(#9)	11-02-83	9436.0	142.38	18.6976	0.0293	3.2470	215.01	2.3266	0.0244	.0049	N/A
840119	0	(#9)	11-03-83	9474.0	168.32	18.6683	0.0338	3.4564	214.51	2.2166	0.0280	.0058	N/A
4x6-Cu - Acid Dipped (#9) 3% O2													
840121	3	(#9)	11-08-83	9534.0	77.82	17.1738	0.0286	2.3220	236.21	2.5907	0.0226	.0060	N/A
840127	3	(#9)	11-09-83	9588.0	94.30	17.1394	0.0315	2.6199	236.12	2.5354	0.0255	.0060	N/A
840133	3	(#9)	11-10-83	9639.0	127.40	17.2610	0.0398	2.8035	233.94	2.5093	0.0339	.0059	N/A
NO CATALYST				**0% O2**									
840139	0	NONE	2-14-84	9764.0	N/A	19.6093	0.4294	6.1118	198.95	2.1862	0.4277	.0017	N/A
840144	0	NONE	2-15-84	9805.0	N/A	19.6649	0.3973	5.1555	200.00	2.3254	0.3964	.0009	N/A
840149	0	NONE	3-08-84	9870.0	N/A	19.7358	0.3831	4.7073	200.07	2.3063	0.3801	.0030	N/A
4x6-Pd+Base Metal(5) (#10) 0% O2													
840154	0	(#10)	3-09-84	9923.3	N/A	19.2203	0.0068	0.1224	213.51	0.8545	0.0051	.0017	N/A
840156	0	(#10)	3-13-84	9962.0	N/A	19.5820	0.0063	0.1479	209.68	0.8939	0.0056	.0007	N/A
840158	0	(#10)	4-04-84	10009.5	N/A	19.2931	0.0082	0.2365	212.65	1.0487	0.0057	.0025	N/A
4x6-Pd+Base Metal(5) (#10) 3% O2													
840160	3	(#10)	4-05-84	10053.9	N/A	17.8202	0.0125	0.0016	230.61	2.6096	0.0079	.0046	N/A
843391	3	(#10)	4-06-84	10096.1	N/A	17.8982	0.0113	0.0000	229.66	2.6230	0.0063	.0050	N/A
843393	3	(#10)	4-10-84	10137.4	N/A	17.5160	0.0124	0.0095	235.48	2.7200	0.0083	.0041	N/A
4x6-Pd+Base Metal(5) (#10) 5% O2													
843395	5	(#10)	4-11-84	10182.9	N/A	17.7420	0.0144	0.0063	231.97	2.6466	0.0097	.0047	N/A

Emissions Data Generated During Idle Operation

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/min)	Mins / Gallon	HC (g/min)	CO (g/min)	CO2 (g/min)	NOx (g/min)	Non-Methane HC (g/min)	METHANE (g/min)	METHANOL (g/min)
4x6-5Pt:Rh(40)			(STOCK)	0% 02									
814214	0	STOCK	6-29-82	2684.0	0.00	122.0	0.0015	0.0029	33.840	0.0017	0.0008	0.0007	0.0017
814217	0	STOCK	6-30-82	2733.4	0.11	114.0	0.0020	0.0027	36.268	0.0000	0.0013	0.0007	0.0021
814220	0	STOCK	7-01-82	2791.0	0.10	119.0	0.0020	0.0053	34.746	0.0000	N/A	N/A	0.0007
814223	0	STOCK	7-02-82	2840.0	0.13	124.0	0.0053	0.1084	33.125	0.0008	0.0041	0.0012	0.0015
NO CATALYST				0% 02									
815242	0	NONE	8-13-82	3184.0	19.97	119.0	0.0861	0.7157	33.094	0.0179	0.0858	0.0003	0.2211
815244	0	NONE	8-17-82	3210.0	19.80	128.0	0.0815	0.7258	30.643	0.0126	0.0818	-0.0003	0.1835
815246	0	NONE	8-17-82	3227.0	20.58	124.0	0.0862	0.7344	32.107	0.0115	0.0859	0.0003	0.1942
NO CATALYST				3% 02									
815252	3	NONE	8-20-82	3327.0	23.55	128.0	0.0873	0.7497	30.513	0.0157	0.0871	0.0002	0.2207
815257	3	NONE	8-25-82	3393.0	15.91	143.0	0.0760	0.5881	27.610	0.0112	N/A	N/A	0.1909
815258	3	NONE	8-26-82	3419.0	15.14	142.0	0.0734	0.5755	27.818	0.0112	N/A	N/A	0.2701
NO CATALYST				5% 02									
815266	5	NONE	9-10-82	3590.5	20.16	121.0	0.0981	0.7702	32.639	0.0150	N/A	N/A	0.3064
815268	5	NONE	9-10-82	3612.7	19.05	120.0	0.0999	0.7356	32.880	0.0139	N/A	N/A	0.2956
815270+	5	NONE	9-14-82	3652.0	17.28	120.0	0.0768	0.7120	32.929	0.0134	N/A	N/A	0.2656
4x6-12Pt:Rh(40)			(#1)	0% 02									
815275	0	(#1)	9-16-82	3737.4	0.03	137.0	0.0011	0.00	30.121	0.0034	0.0001	0.0010	0.0043
815993	0	(#1)	9-21-82	3818.3	0.04	129.0	0.0045	0.00	31.840	0.0034	0.0029	0.0016	0.0078
4x6-12Pt:Rh(40)			(#1)	3% 02									
816001	3	(#1)	9-29-82	3971.8	0.37	125.0	0.0022	0.0059	32.965	0.0146	0.0015	0.0007	0.0014
4x6-12Pt:Rh(40)			(#1)	5% 02									
816005	5	(#1)	9-30-82	4032.0	0.75	122.0	0.0021	0.00	33.700	0.0151	0.0012	0.0009	0.0021
816007	5	(#1)	10-01-82	4045.0	0.84	114.0	0.0021	0.00	36.097	0.0081	0.0012	0.0009	0.0022
816009	5	(#1)	10-01-82	4078.0	1.33	130.0	0.0021	0.00	31.612	0.0099	0.0011	0.0010	N/A
4x6-12Pt:Rh(40)			(#1)	3% 02	(AGAIN)								
816016	3	(#1)	10-08-82	4228.3	N/A	133.0	0.0266	0.1719	30.577	0.0248	0.0254	0.0012	0.0137
816018	3	(#1)	10-08-82	4233.2	0.28	134.0	0.0034	0.0028	30.787	0.0128	0.0028	0.0006	0.0149
NO CATALYST				0% 02									
816024	0	NONE	10-14-82	4351.0	10.02	146.0	0.0878	0.6021	26.964	0.0196	0.0874	0.0004	0.2467
6xRTO-12Pt:Rh(40)			(#2)	0% 02									
816029	0	(#2)	10-19-82	4444.0	0.45	146.0	0.0030	0.00	28.273	0.0053	0.0024	0.0006	0.0126
816570	0	(#2)	11-02-82	4623.2	1.34	134.0	0.0020	0.00	30.639	0.0169	0.0013	0.0007	N/A

Emissions Data Generated During Idle Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/min)	Mins / Gallon	HC (g/min)	CO (g/min)	CO2 (g/min)	NOx (g/min)	Non-Methane HC (g/min)	METHANE (g/min)	METHANOL (g/min)
6xRTO-12Pt:Rh(40) (#2)				5% O2									
816578	5	(#2)	11-05-82	4765.0	1.52	119.0	0.0037	0.0056	34.498	0.0231	0.0030	0.0007	0.0069
816582+	5	(#2)	11-18-82	4820.0	N/A	113.0	0.0034	0.0003	36.453	0.0115	0.0026	0.0008	0.0060
NO CAT CHECK OUT				5% O2									
816585+	5	NONE	11-19-82	4888.0	0.94	123.0	0.0868	0.6445	32.148	0.0240	0.0856	0.0012	N/A
NO CATALYST				0% O2									
816592+	0	NONE	12-01-82	5027.0	19.96	137.0	0.0941	0.5186	28.956	0.0258	0.0937	0.0004	0.2956
816598	0	NONE	12-07-82	5137.0	13.46	136.0	0.1117	0.6316	28.825	0.0290	0.1113	0.0004	N/A
816602	0	NONE	12-08-82	5188.0	12.45	142.0	0.0882	0.6407	27.786	0.0332	0.0870	0.0012	N/A
4x6-3Pt:2Pd(20) (#3)				0% O2									
816610	0	(#3)	12-14-82	5319.0	N/A	134.0	0.0027	0.0027	30.789	0.0093	N/A	N/A	N/A
816612	0	(#3)	12-15-82	5338.0	N/A	132.0	0.0047	0.0003	31.289	0.0052	0.0041	0.0006	N/A
4x6-3Pt:2Pd(20) (#3)				3% O2									
816615	3	(#3)	12-16-82	5400.0	N/A	115.0	0.0058	0.0001	35.781	0.0237	0.0051	0.0007	N/A
816619	3	(#3)	12-17-82	5448.0	N/A	112.0	0.0715	0.2712	36.091	0.0329	0.0708	0.0007	N/A
817460	3	(#3)	12-21-82	5499.0	10.38	124.0	0.0192	0.0560	33.116	0.0246	0.0183	0.0009	0.0342
4x6-3Pt:2Pd(20) (#3)				5% O2									
817466	5	(#3)	1-04-83	5598.6	49.64	111.0	0.0359	0.0029	36.884	0.0141	N/A	N/A	N/A
817468	5	(#3)	1-04-83	5609.0	56.26	121.0	0.0709	0.0056	33.710	0.0188	N/A	N/A	N/A
NO CATALYST				0% O2									
817472	0	NONE	1-05-83	5662.0	6.98	109.0	0.1591	0.8313	36.002	0.0456	N/A	N/A	N/A
4x6-Pd(40) (#4)				0% O2									
817474	0	(#4)	1-06-83	5674.0	14.16	119.0	0.1371	0.4931	33.535	0.0240	N/A	N/A	0.4315
817482	0	(#4)	1-12-83	5805.0	< 0.45	121.0	0.0024	0.0029	33.894	0.0041	0.0017	0.0007	N/A
4x6-Pd(40) (#4)				3% O2									
817486	3	(#4)	1-13-83	5865.0	4.04	123.0	0.0044	0.0001	33.394	0.0108	0.0038	0.0006	N/A
817490	3	(#4)	1-14-83	5912.0	11.16	124.0	0.0081	0.0031	33.179	0.0123	0.0066	0.0015	N/A
4x6-Pd(40) (#4)				5% O2									
817493	5	(#4)	1-18-83	5966.6	26.82	121.0	0.0098	0.0084	34.051	0.0082	0.0086	0.0012	N/A
817497	5	(#4)	1-19-83	6017.0	29.11	116.0	0.0164	0.0026	35.412	0.0224	0.0149	0.0015	N/A
4x6-Pd(40) (#4)				0% O2	(AGAIN)								
817920	0	(#4)	1-25-83	6066.0	11.59	119.0	0.0139	0.0029	34.632	0.0084	0.0130	0.0009	N/A

Emissions Data Generated During Idle Operation (Continued)

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/min)	Mins / Gallon	HC (g/min)	CO (g/min)	CO2 (g/min)	NOx (g/min)	Non-Meth-ane HC (g/min)	METHANE (g/min)	METHANOL (g/min)
NO CATALYST				**0% 02**									
817923	0	NONE	1-27-83	6116.0	24.12	N/A	0.1133	1.047	N/A	0.0242	0.1122	0.0011	N/A
4x6-Pd+Base Metal(35) (#5)				**0% 02**									
817927+	0	(#5)	1-28-83	6168.0	N/A	N/A	0.0724	0.4728	N/A	0.0211	0.0716	0.0008	N/A
817931+	0	(#5)	2-01-83	6222.0	N/A	N/A	0.1084	0.5110	N/A	0.0259	0.1073	0.0011	N/A
4x6-Pd+Base Metal(35) (#5)				**3% 02**									
817935+	3	(#5)	2-02-83	6277.0	N/A	132.0	0.0997	0.6692	29.871	0.0299	0.0986	0.0011	N/A
4x6-Pd+Base Metal(35) (#5)				**0% 02**									
817941	0	(#5)	2-09-83	6425.0	13.24	136.0	0.0805	0.3648	29.361	0.0244	0.0795	0.0010	N/A
817945	0	(#5)	2-10-83	6477.0	13.38	N/A	0.0897	0.4169	N/A	0.0231	0.0889	0.0008	N/A
4x6-Pd+Base Metal(35) (#5)				**3% 02**									
817949	3	(#5)	2-11-83	6533.0	N/A	N/A	0.0999	0.4517	N/A	0.0244	0.0982	0.0017	N/A
817953	3	(#5)	2-15-83	6587.0	N/A	128.0	0.1222	0.4059	31.261	0.0299	0.1218	0.0004	N/A
4x6-Pd+Base Metal(35) (#5)				**5% 02**									
818394	5	(#5)	2-17-83	6685.0	N/A	118.0	0.1337	0.6420	33.424	0.0456	0.1318	0.0019	N/A
818398	5	(#5)	2-18-83	6741.0	N/A	123.0	0.1365	0.6009	32.014	0.0431	0.1353	0.0012	N/A
4x6-Cu Mesh (#6)				**0% 02**									
818406	0	(#6)	2-24-83	6871.0	N/A	127.0	0.1473	0.5354	31.234	0.0329	0.1458	0.0015	N/A
818410	0	(#6)	2-25-83	6927.2	N/A	124.0	0.1436	0.6254	31.716	0.0262	0.1421	0.0015	N/A
4x6-Cu Mesh (#6)				**3% 02**									
818414	3	(#6)	3-01-83	6997.0	N/A	118.0	0.1611	0.5907	33.317	0.0264	0.1604	0.0007	N/A
818646	3	(#6)	3-02-83	7047.7	N/A	121.0	0.1401	0.8202	32.273	0.0279	0.1391	0.0010	N/A
4x6-Cu Mesh (#6)				**5% 02**									
818650	5	(#6)	3-03-83	7104.6	N/A	112.0	0.1566	0.6746	35.190	0.0302	0.1547	0.0019	N/A
818654	5	(#6)	3-04-83	7156.0	N/A	118.0	0.1705	0.5711	33.575	0.0296	0.1698	0.0007	N/A
4x6-Pd(20) (#7)				**0% 02**									
818662	0	(#7)	3-10-83	7288.7	N/A	124.0	0.0272	0.2243	32.690	0.0066	0.0260	0.0012	N/A
818666	0	(#7)	3-11-83	7345.0	N/A	109.0	0.0766	0.1233	37.319	0.0127	0.0750	0.0016	N/A
818723	0	(#7)	3-15-83	7396.0	N/A	127.0	0.0015	0.0677	32.199	0.0008	0.0005	0.0010	N/A
4x6-Pd(20) (#7)				**3% 02**									
818727	3	(#7)	3-16-83	7452.0	N/A	124.0	0.0116	0.0023	33.168	0.0155	0.0109	0.0007	N/A
818731	3	(#7)	3-17-83	7504.0	N/A	126.0	0.0075	0.0083	32.526	0.0229	0.0063	0.0012	N/A

Emissions Data Generated During Idle Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/min)	Mins / Gallon	HC (g/min)	CO (g/min)	CO2 (g/min)	NOx (g/min)	Non-Methane HC (g/min)	METHANE (g/min)	METHANOL (g/min)
4x6-Pd(20) (#7)				**5% O2**									
818735	5	(#7)	3-18-83	7561.0	N/A	123.0	0.0233	0.0028	33.275	0.0243	0.0219	0.0014	N/A
818739	5	(#7)	3-22-83	7611.0	N/A	123.0	0.0207	0.0055	33.326	0.0235	N/A	N/A	N/A
818976	5	(#7)	3-23-83	7663.0	N/A	119.0	0.0287	0.0001	34.482	0.0271	N/A	N/A	N/A
4x6-Ag(150) (#8)				**0% O2**									
818992	0	(#8)	4-07-83	7971.0	N/A	132.0	0.0663	0.4556	30.292	0.0198	0.0655	0.0008	N/A
818996	0	(#8)	4-08-83	8023.0	N/A	123.0	0.0415	0.4889	32.637	0.0187	0.0402	0.0013	N/A
4x6-Ag(150) (#8)				**3% O2**									
819243	3	(#8)	4-21-83	8254.0	N/A	104.0	0.1259	0.8400	37.774	0.0241	0.1241	0.0018	N/A
819247	3	(#8)	4-22-83	8326.8	N/A	122.0	0.0538	0.7222	32.433	0.0164	0.0523	0.0015	N/A
4x6-Ag(150) (#8)				**5% O2**									
819254	5	(#8)	4-29-83	8455.5	N/A	111.0	0.1020	0.9658	35.105	0.0256	0.1005	0.0015	N/A
819258	5	(#8)	5-04-83	8493.5	N/A	116.0	0.1176	0.8220	33.803	0.0245	0.1164	0.0012	N/A
NO CATALYST				**0% O2**									
819273	0	NONE	5-24-83	8762.0	N/A	130.0	0.0914	0.9837	29.919	0.0189	0.0899	0.0015	N/A
819279	0	NONE	5-25-83	8813.0	N/A	138.0	0.1059	0.9912	27.884	0.0246	0.1047	0.0012	N/A
820324	0	NONE	5-26-83	8864.0	N/A	139.0	0.0957	0.9613	27.783	0.0246	0.0942	0.0015	N/A
820376	0	NONE	7-06-83	8983.0	N/A	127.0	0.0933	0.7266	30.975	0.0186	0.0918	0.0015	N/A
820381	0	NONE	7-07-83	9023.0	N/A	128.0	0.0882	0.6847	30.792	0.0161	0.0867	0.0015	N/A
4x6-Cu - Acid Dipped (#9)				**3% O2**									
840122	3	(#9)	11-08-83	9547.0	N/A	127.0	0.0986	0.4588	31.275	0.0199	0.0976	0.0010	N/A
840128	3	(#9)	11-09-83	9598.0	N/A	128.0	0.0279	0.3218	31.653	0.0161	0.0268	0.0011	N/A
840134	3	(#9)	11-10-83	9642.0	N/A	132.0	0.0239	0.2801	30.719	0.0163	0.0232	0.0007	N/A

Emissions Data Generated During 10 MPH Steady State Operation

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-12Pt:Rh(40) (#1)				**0% 02**									
816032	0	(#1)	9-16-82	3747.0	1.9	10.0	0.028	0.0	412.091	0.010	0.026	.0020	0.060
815993	0	(#1)	9-21-82	3818.3	0.2	10.1	0.012	0.0	407.333	0.045	0.002	.0100	0.008
4x6-12Pt:Rh(40) (#1)				**3% 02**									
816001	3	(#1)	9-29-82	3971.8	1.3	10.1	0.022	0.016	407.998	0.284	0.009	.0130	0.007
4x6-12Pt:Rh(40) (#1)				**5% 02**									
816005	5	(#1)	9-30-82	4032.0	1.8	10.1	0.019	0.016	406.680	0.331	0.007	.0120	0.007
816007	5	(#1)	10-01-82	4045.0	3.7	9.6	0.025	0.0	430.273	0.295	0.012	.0130	0.013
816009	5	(#1)	10-01-82	4078.0	5.8	10.1	0.025	0.0	406.958	0.302	0.012	.0130	N/A
4x6-12Pt:Rh(40) (#1)				**3% 02**	**(AGAIN)**								
816016	3	(#1)	10-08-82	4228.3	4.7	10.3	0.038	0.034	382.462	0.301	0.025	.0130	0.006
816018	3	(#1)	10-08-82	4233.2	11.7	10.4	0.024	0.033	394.687	0.285	0.013	.0110	0.009
NO CATALYST				**0% 02**									
816024	0	NONE	10-14-82	4351.0	109.2	10.2	0.427	11.387	382.462	0.261	0.415	.0120	1.046
6xRTO-12Pt:Rh(40) (#2)				**0% 02**									
816029	0	(#2)	10-19-82	4444.0	0.2	10.5	0.020	0.0	391.840	0.196	0.010	.0100	0.161
816570	0	(#2)	11-02-82	4623.2	2.0	10.2	0.021	0.0	402.966	0.267	0.011	.0100	N/A
6xRTO-12Pt:Rh(40) (#2)				**5% 02**									
816578	5	(#2)	11-05-82	4765.0	1.8	10.0	0.023	0.018	413.033	0.304	0.014	.0090	0.022
816582+	5	(#2)	11-18-82	4820.0	2.7	9.5	0.027	0.020	433.838	0.290	0.014	.0130	0.011
NO CATALYST				**0% 02**									
816592+	0	NONE	12-01-82	5027.0	133.4	9.6	0.412	8.879	415.744	0.331	0.401	.0110	1.174
816598	0	NONE	12-07-82	5137.0	151.2	9.9	0.396	9.706	397.574	0.330	0.387	.0090	N/A
816602	0	NONE	12-08-82	5188.0	129.4	10.0	0.433	10.408	394.668	0.335	0.419	.0140	N/A
4x6-3Pt:2Pd(20) (#3)				**0% 02**									
816610	0	(#3)	12-14-82	5319.0	N/A	10.2	0.022	0.235	404.822	0.045	N/A	N/A	N/A
816612	0	(#3)	12-15-82	5338.0	N/A	9.8	0.040	0.154	418.207	0.041	0.030	.0100	N/A
4x6-3Pt:2Pd(20) (#3)				**3% 02**									
816615	3	(#3)	12-16-82	5400.0	N/A	9.7	0.025	0.001	424.816	0.279	0.013	.0120	N/A
816619	3	(#3)	12-17-82	5448.0	N/A	9.6	0.090	0.222	429.683	0.339	0.075	.0150	N/A
817460	3	(#3)	12-21-82	5499.0	64.80	9.8	0.038	0.0	421.589	0.308	0.023	.0150	0.036
4x6-3Pt:2Pd(20) (#3)				**5% 02**									
817466	5	(#3)	1-04-83	5598.6	293.06	9.8	0.102	0.001	421.831	0.258	N/A	N/A	N/A
N/A	5	(#3)	1-04-83	5600.0	294.49	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Emissions Data Generated During 10 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				0% O2									
817472	0	NONE	1-05-83	5662.0	106.85	9.9	0.528	10.429	396.796	0.365	N/A	N/A	N/A
4x6-Pd(40) (#4)				0% O2									
817474	0	(#4)	1-06-83	5674.0	41.53	9.8	0.176	3.459	415.500	0.041	N/A	N/A	0.517
817482	0	(#4)	1-12-83	5805.0	< 2.13	9.8	0.033	1.644	417.695	0.005	0.020	.0130	N/A
4x6-Pd(40) (#4)				3% O2									
817486	3	(#4)	1-13-83	5865.0	28.4	9.7	0.043	0.002	422.212	0.263	0.027	.0160	N/A
817490	3	(#4)	1-14-83	5912.0	44.0	10.2	0.043	0.036	403.611	0.243	0.025	.0180	N/A
4x6-Pd(40) (#4)				5% O2									
817493	5	(#4)	1-18-83	5966.6	81.2	9.7	0.036	0.003	426.404	0.237	0.018	.0180	N/A
817497	5	(#4)	1-19-83	6017.0	134.5	9.6	0.061	0.021	428.430	0.260	0.046	.0150	N/A
4x6-Pd(40) (#4)				0% O2	(AGAIN)								
817920	0	(#4)	1-25-83	6066.0	35.05	9.7	0.103	3.569	417.534	0.030	0.090	.0130	N/A
NO CATALYST				0% O2									
817923	0	NONE	1-27-83	6116.0	226.62	N/A	0.602	13.445	N/A	0.300	0.591	.0110	N/A
4x6-Pd+Base Metal(35) (#5)				0% O2									
817927+	0	(#5)	1-28-83	6168.0	N/A	N/A	0.392	8.070	N/A	0.282	0.381	.0110	N/A
817931+	0	(#5)	2-01-83	6222.0	N/A	N/A	0.485	8.279	N/A	0.285	0.475	.0100	N/A
4x6-Pd+Base Metal(35) (#5)				3% O2									
817935+	3	(#5)	2-02-83	6277.0	N/A	10.1	0.372	8.784	392.571	0.293	0.362	.0100	N/A
4x6-Pd+Base Metal(35) (#5)				0% O2									
817941	0	(#5)	2-09-83	6425.0	69.3	10.3	0.303	5.398	390.249	0.286	0.292	.0110	N/A
817945	0	(#5)	2-10-83	6477.0	82.05	N/A	0.261	4.916	N/A	0.296	0.249	.0120	N/A
4x6-Pd+Base Metal(35) (#5)				3% O2									
817949	3	(#5)	2-11-83	6533.0	N/A	N/A	0.287	5.018	N/A	0.286	0.271	.0160	N/A
817953	3	(#5)	2-15-83	6587.0	N/A	10.1	0.376	5.286	398.10	0.323	0.362	.0140	N/A
4x6-Pd+Base Metal(35) (#5)				5% O2									
818394	5	(#5)	2-17-83	6685.0	N/A	9.9	0.549	9.753	398.331	0.341	0.534	.0150	N/A
818398	5	(#5)	2-18-83	6741.0	N/A	10.1	0.531	8.405	394.560	0.329	0.517	.0140	N/A
4x6-Cu Mesh (#6)				0% O2									
818406	0	(#6)	2-24-83	6871.0	N/A	10.1	0.671	7.989	391.295	0.308	0.656	.0150	N/A
818410	0	(#6)	2-25-83	6927.2	N/A	10.1	0.628	7.625	393.257	0.305	0.615	.0130	N/A

Emissions Data Generated During 10 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Cu Mesh (#6)				**3% O2**									
818414	3	(#6)	3-01-83	6997.0	N/A	10.0	0.575	7.676	397.248	0.301	0.565	.0100	N/A
818646	3	(#6)	3-02-83	7047.7	N/A	10.1	0.543	8.652	393.277	0.293	0.530	.0130	N/A
4x6-Cu Mesh (#6)				**5% O2**									
818650	5	(#6)	3-03-83	7104.6	N/A	9.9	0.608	8.084	401.134	0.307	0.593	.0150	N/A
818654	5	(#6)	3-04-83	7156.0	N/A	10.1	0.677	8.208	394.334	0.322	0.665	.0120	N/A
4x6-Pd(20) (#7)				**0% O2**									
818662	0	(#7)	3-10-83	7288.7	N/A	10.1	0.200	2.014	402.210	0.045	0.187	.0130	N/A
818666	0	(#7)	3-11-83	7345.0	N/A	10.1	0.265	2.429	402.880	0.046	0.249	.0160	N/A
818723	0	(#7)	3-15-83	7396.0	N/A	10.1	0.039	2.213	403.175	0.010	0.023	.0160	N/A
4x6-Pd(20) (#7)				**3% O2**									
818727	3	(#7)	3-16-83	7452.0	N/A	10.0	0.074	0.021	413.021	0.279	0.058	.0160	N/A
818731	3	(#7)	3-17-83	7504.0	N/A	10.1	0.071	0.035	407.281	0.281	0.058	.0130	N/A
4x6-Pd(20) (#7)				**5% O2**									
818735	5	(#7)	3-18-83	7561.0	N/A	10.1	0.112	0.066	405.92	0.271	0.0963	.0157	N/A
818739	5	(#7)	3-22-83	7611.0	N/A	10.1	0.109	0.018	405.27	0.276	N/A	N/A	N/A
818976	5	(#7)	3-23-83	7663.0	N/A	9.9	0.106	0.051	414.168	0.275	N/A	N/A	N/A
4x6-Ag(150) (#8)				**0% O2**									
818992	0	(#8)	4-07-83	7971.0	N/A	10.2	0.290	6.839	391.652	0.298	0.280	.0100	N/A
818996	0	(#8)	4-08-83	8023.0	N/A	9.9	0.197	6.491	403.087	0.292	0.1838	.0132	N/A
4x6-Ag(150) (#8)				**3% O2**									
819243	3	(#8)	4-21-83	8254.0	N/A	9.8	0.548	9.261	401.849	0.367	0.5347	.0133	N/A
819247	3	(#8)	4-22-83	8326.8	N/A	10.1	0.216	9.601	390.667	0.251	0.2160	.0000	N/A
4x6-Ag(150) (#8)				**5% O2**									
819255	5	(#8)	4-29-83	8457.0	N/A	9.8	0.426	10.455	402.714	0.287	0.4077	.0183	N/A
819259	5	(#8)	5-04-83	8495.8	N/A	10.0	0.653	9.516	395.964	0.307	0.6382	.0148	N/A
NO CATALYST				**0% O2**									
819274	0	NONE	5-24-83	8762.0	N/A	10.5	0.382	10.106	373.660	0.201	0.3656	.0164	N/A
819280	0	NONE	5-25-83	8813.0	N/A	10.2	0.503	11.804	382.885	0.268	0.4863	.0167	N/A
820325	0	NONE	5-26-83	8864.0	N/A	10.1	0.459	10.866	387.586	0.257	0.4413	.0177	N/A
820377	0	NONE	7-06-83	8983.0	N/A	10.8	0.327	6.986	369.113	0.205	0.3142	.0128	N/A
820382	0	NONE	7-07-83	9025.0	N/A	10.2	0.531	6.927	390.734	0.204	0.5166	.0144	N/A
4x6-Cu - Acid Dipped (#9)				**3% O2**									
840123	3	(#9)	11-08-83	9547.0	N/A	10.2	0.374	5.757	393.649	0.286	0.3637	.0103	N/A
840129	3	(#9)	11-09-83	9600.0	N/A	10.3	0.336	5.930	389.884	0.270	0.3239	.0121	N/A
840135	3	(#9)	11-10-83	9648.0	N/A	10.6	0.367	5.520	380.015	0.278	0.3585	.0085	N/A

Emissions Data Generated During 10 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
NO CATALYST				0% O2									
840140	0	NONE	2-14-84	9774.5	N/A	11.5	0.359	6.779	345.147	0.173	0.3546	.0044	N/A
840145	0	NONE	2-15-84	9827.5	N/A	11.3	0.354	6.843	352.196	0.180	0.3520	.0020	N/A
840150	0	NONE	3-08-84	9882.2	N/A	11.2	0.404	6.986	356.356	0.221	0.3969	.0071	N/A

Emissions Data Generated During 20 MPH Steady State Operation

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-5Pt:Rh(40)			(STOCK)	**0% O2**									
814214	0	STOCK	6-29-82	2684.0	0.2	19.8	0.005	0.017	207.976	0.005	0.001	.0040	0.003
814217	0	STOCK	6-30-82	2733.4	0.3	19.4	0.005	0.016	211.969	-0.002	0.001	.0040	0.005
814220	0	STOCK	7-01-82	2791.0	0.2	18.9	0.008	0.016	217.309	0.0	N/A	N/A	0.001
814223	0	STOCK	7-02-82	2840.0	0.2	19.4	0.010	0.150	211.960	0.0	0.005	.0050	0.002
NO CATALYST				**0% O2**									
815242	0	NONE	8-13-82	3184.0	158.8	19.3	0.396	4.549	205.257	0.476	0.393	.0030	1.219
815244	0	NONE	8-17-82	3210.0	163.1	19.2	0.387	4.303	206.141	0.531	0.386	.0010	0.873
815246	0	NONE	8-17-82	3227.0	164.5	19.2	0.377	4.255	206.385	0.479	0.376	.0010	0.854
NO CATALYST				**3% O2**									
815252	3	NONE	8-20-82	3327.0	151.2	19.9	0.334	4.312	198.650	0.442	0.332	.0020	0.826
815257	3	NONE	8-25-82	3393.0	133.8	19.4	0.348	4.053	204.728	0.496	N/A	N/A	1.012
815258	3	NONE	8-26-82	3419.0	84.8	19.6	0.334	3.813	203.511	0.473	N/A	N/A	1.298
NO CATALYST				**5% O2**									
815266	5	NONE	9-10-82	3590.5	105.9	18.9	0.344	4.425	209.483	0.437	N/A	N/A	1.298
815268	5	NONE	9-10-82	3612.7	104.2	19.1	0.326	4.307	207.280	0.427	N/A	N/A	1.084
815270+	5	NONE	9-14-82	3652.0	127.9	19.4	0.324	4.203	204.531	0.392	N/A	N/A	1.115
4x6-12Pt:Rh(40)			(#1)	**0% O2**									
816032	0	(#1)	9-16-82	3747.0	0.7	19.6	0.005	0.008	209.625	0.008	0.004	.0010	0.022
815994	0	(#1)	9-21-82	3828.0	2.2	19.8	0.011	0.025	207.955	0.053	0.009	.0020	0.016
4x6-12Pt:Rh(40)			(#1)	**3% O2**									
816002	3	(#1)	9-29-82	3983.0	1.0	19.4	0.010	0.0	211.833	0.413	0.006	.0040	0.004
4x6-12Pt:Rh(40)			(#1)	**5% O2**									
816008	5	(#1)	10-01-82	4065.0	1.1	19.4	0.008	0.0	212.446	0.492	0.004	.0040	0.002
816010	5	(#1)	10-01-82	4100.0	1.6	19.4	0.007	0.0	212.181	0.448	0.004	.0030	N/A
4x6-12Pt:Rh(40)			(#1)	**3% O2**	**(AGAIN)**								
816017	3	(#1)	10-08-82	4229.9	N/A	19.8	0.011	0.001	208.343	0.480	0.005	.0060	0.005
816019	3	(#1)	10-08-82	4236.5	2.6	19.5	0.039	0.279	210.177	0.540	0.034	.0050	0.036
NO CATALYST				**0% O2**									
816025	0	NONE	10-14-82	4353.0	97.2	19.5	0.381	4.211	203.749	0.579	0.378	.0030	0.977
6xRTO-12Pt:Rh(40)			(#2)	**0% O2**									
816563	0	(#2)	10-19-82	4450.0	0.8	20.3	0.008	0.0	202.953	0.133	0.005	.0030	0.039
816571	0	(#2)	11-02-82	4625.0	1.5	19.6	0.010	0.0	210.063	0.413	0.007	.0030	N/A

Emissions Data Generated During 20 MPH Steady State Operation (Continued)

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
6xRTO-12Pt:Rh(40) (#2)				**5% 02**									
816579	5	(#2)	11-05-82	4768.0	1.5	19.4	0.010	0.009	212.475	0.471	0.007	.0030	0.101
816582+	5	(#2)	11-18-82	4820.0	2.1	17.0	0.011	0.019	242.229	0.340	0.004	.0070	0.023
NO CAT CHECK OUT				**5% 02**									
816585+	5	NONE	11-19-82	4888.0	N/A	16.2	0.256	4.480	245.691	0.356	0.251	.0050	N/A
NO CATALYST				**0% 02**									
816599	0	NONE	12-07-82	5140.0	98.61	19.5	0.343	4.582	203.264	0.493	0.338	.0050	N/A
816603	0	NONE	12-08-82	5192.0	94.27	19.1	0.399	4.762	206.711	0.521	0.395	.0040	N/A
4x6-3Pt:2Pd(20) (#3)				**0% 02**									
816611	0	(#3)	12-14-82	5321.0	N/A	18.9	0.030	0.451	216.899	0.056	N/A	N/A	N/A
816613	0	(#3)	12-15-82	5343.0	N/A	19.0	0.011	0.604	216.275	0.051	0.007	.0040	N/A
4x6-3Pt:2Pd(20) (#3)				**3% 02**									
816616	3	(#3)	12-16-82	5403.0	N/A	18.8	0.012	0.0	219.108	0.430	0.008	.0040	N/A
816620	3	(#3)	12-17-82	5454.0	N/A	18.4	0.029	-0.015	223.884	0.538	0.023	.0060	0.055
817461	3	(#3)	12-21-82	5504.0	70.58	19.2	0.018	0.0	214.202	0.477	0.012	.0060	0.047
4x6-3Pt:2Pd(20) (#3)				**5% 02**									
817467	5	(#3)	1-04-83	5599.6	165.52	19.1	0.097	0.009	215.616	0.423	N/A	N/A	N/A
817469	5	(#3)	1-04-83	5612.0	144.94	17.7	0.174	0.309	231.697	0.380	N/A	N/A	N/A
NO CATALYST				**0% 02**									
817473	0	NONE	1-05-83	5668.0	73.74	21.1	0.409	5.024	185.760	0.475	N/A	N/A	N/A
4x6-Pd(40) (#4)				**0% 02**									
817475	0	(#4)	1-06-83	5680.0	19.83	17.9	0.120	1.276	227.161	0.052	N/A	N/A	0.322
817483	0	(#4)	1-12-83	5808.0	20.8	18.1	0.134	1.615	224.514	0.037	0.128	.0060	N/A
4x6-Pd(40) (#4)				**3% 02**									
817487	3	(#4)	1-13-83	5869.0	113.6	18.9	0.055	0.009	217.800	0.389	0.051	.0040	N/A
817491	3	(#4)	1-14-83	5921.0	91.5	18.5	0.039	0.018	221.824	0.459	0.034	.0050	N/A
4x6-Pd(40) (#4)				**5% 02**									
817494	5	(#4)	1-18-83	5968.4	138.9	18.6	0.039	0.018	221.602	0.374	0.032	.0070	N/A
817498+	5	(#4)	1-19-83	6020.0	108.5	17.2	0.171	0.069	239.240	0.668	0.166	.0050	N/A
NO CATALYST				**0% 02**									
817924	0	NONE	1-27-83	6118.0	165.45	N/A	0.477	6.459	N/A	0.489	0.472	.0050	N/A
4x6-Pd+Base Metal(35) (#5)				**0% 02**									
817928+	0	(#5)	1-28-83	6172.0	N/A	N/A	0.222	4.255	N/A	0.417	0.218	.0040	N/A
817932+	0	(#5)	2-01-83	6225.0	N/A	N/A	0.347	4.759	N/A	0.457	0.344	.0030	N/A

Emissions Data Generated During 20 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Pd+Base Metal(35) (#5) 3% O2													
817936+	3	(#5)	2-02-83	6282.0	N/A	18.8	0.346	4.977	210.618	0.532	0.341	.0050	N/A
4x6-Pd+Base Metal(35) (#5) 0% O2													
817942	0	(#5)	2-09-83	6428.0	61.38	19.5	0.295	3.095	204.865	0.452	0.292	.0030	N/A
817946+	0	(#5)	2-10-83	6481.0	5.11	N/A	0.363	3.404	N/A	0.519	0.359	.0040	N/A
4x6-Pd+Base Metal(35) (#5) 3% O2													
817950+	3	(#5)	2-11-83	6535.0	N/A	N/A	0.394	3.453	N/A	0.403	0.389	.0050	N/A
817954	3	(#5)	2-15-83	6591.0	N/A	18.9	0.428	4.171	210.091	0.528	0.422	.0060	N/A
4x6-Pd+Base Metal(35) (#5) 5% O2													
818395	5	(#5)	2-17-83	6688.0	N/A	18.4	0.461	4.476	215.243	0.445	0.455	.0060	N/A
818399	5	(#5)	2-18-83	6743.0	N/A	19.7	0.410	4.117	201.220	0.409	0.404	.0060	N/A
4x6-Cu Mesh (#6) 0% O2													
818407	0	(#6)	2-24-83	6874.0	N/A	19.3	0.545	4.226	205.099	0.515	0.538	.0070	N/A
818411	0	(#6)	2-25-83	6930.0	N/A	18.7	0.596	4.197	211.748	0.507	0.590	.0060	N/A
4x6-Cu Mesh (#8) 3% O2													
818415	3	(#6)	3-01-83	7000.0	N/A	19.1	0.500	3.665	208.055	0.478	0.494	.0060	N/A
818647	3	(#6)	3-02-83	7053.2	N/A	18.8	0.542	4.453	209.772	0.550	0.538	.0040	N/A
4x6-Cu Mesh (#8) 5% O2													
818651	5	(#6)	3-03-83	7108.8	N/A	19.1	0.470	3.662	208.633	0.488	0.465	.0050	N/A
818655	5	(#6)	3-04-83	7159.1	N/A	19.4	0.444	3.808	204.615	0.420	0.439	.0050	N/A
4x6-Pd(20) (#7) 0% O2													
818663	0	(#7)	3-10-83	7294.7	N/A	19.4	0.062	0.925	210.324	0.025	0.057	.0050	N/A
818667	0	(#7)	3-11-83	7348.0	N/A	18.9	0.168	0.426	216.848	0.124	0.162	.0060	N/A
818724	0	(#7)	3-15-83	7399.0	N/A	19.0	0.032	1.211	214.841	0.023	0.026	.0060	N/A
4x6-Pd(20) (#7) 3% O2													
818728	3	(#7)	3-16-83	7454.0	N/A	19.4	0.118	0.058	211.523	0.384	0.112	.0060	N/A
818732	3	(#7)	3-17-83	7506.0	N/A	18.9	0.074	0.018	217.605	0.348	0.070	.0040	N/A
4x6-Pd(20) (#7) 5% O2													
818736	5	(#7)	3-18-83	7563.0	N/A	19.6	0.128	0.009	209.43	0.368	0.123	.0050	N/A
818740	5	(#7)	3-22-83	7614.0	N/A	19.3	0.036	0.008	212.70	0.410	N/A	N/A	N/A
818977	5	(#7)	3-23-83	7666.0	N/A	19.0	0.091	0.001	216.139	0.442	N/A	N/A	N/A
4x6-Ag(150) (#8) 0% O2													
818993	0	(#8)	4-07-83	7974.8	N/A	19.5	0.323	3.424	205.155	0.426	0.319	.0040	N/A
818997	0	(#8)	4-08-83	8026.0	N/A	18.4	0.285	3.401	217.318	0.426	0.2797	.0053	N/A

Emissions Data Generated During 20 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Ag(150) (#8)				**3% O2**									
819244	3	(#8)	4-21-83	8259.0	N/A	19.4	0.198	4.199	205.312	0.317	0.1914	.0066	N/A
819248	3	(#8)	4-22-83	8392.0	N/A	18.8	0.309	4.319	211.220	0.334	N/A	N/A	N/A
4x6-Ag(150) (#8)				**5% O2**									
819256	5	(#8)	4-29-83	8459.0	N/A	19.0	0.365	5.194	207.803	0.370	0.3578	.0072	N/A
819260	5	(#8)	5-04-83	8500.0	N/A	19.6	0.366	4.473	201.985	0.320	0.3608	.0052	N/A
NO CATALYST				**0% O2**									
819275	0	NONE	5-24-83	8764.0	N/A	20.4	0.364	5.300	191.954	0.227	0.3573	.0067	N/A
819281	0	NONE	5-25-83	8816.0	N/A	19.1	0.487	5.622	204.770	0.431	0.4817	.0053	N/A
820326	0	NONE	5-26-83	8868.0	N/A	19.6	0.430	5.069	201.246	0.386	0.4230	.0070	N/A
820378	0	NONE	7-06-83	8986.0	N/A	20.4	0.259	3.845	194.877	0.216	0.2530	.0060	N/A
820383	0	NONE	7-07-83	9027.0	N/A	19.9	0.391	3.687	199.489	0.227	0.3848	.0062	N/A
820386	0	NONE	7-08-83	9057.0	N/A	19.1	0.494	3.620	208.222	0.292	0.4872	.0068	N/A
4x6-Cu - Acid Dipped (#9)				**3% O2**									
840124	3	(#9)	11-08-83	9550.0	N/A	19.6	0.372	3.012	203.733	0.484	0.3679	.0041	N/A
840130	3	(#9)	11-09-83	9600.0	N/A	19.7	0.394	3.354	201.977	0.400	0.3900	.0040	N/A
840136	3	(#9)	11-10-83	9651.0	N/A	20.2	0.377	3.056	197.817	0.388	0.3729	.0041	N/A
NO CATALYST				**0% O2**									
840141	0	NONE	2-14-84	9776.4	N/A	22.4	0.365	3.821	176.745	0.238	0.3628	.0022	N/A
840146	0	NONE	2-15-84	9829.5	N/A	22.2	0.310	3.756	178.297	0.198	0.3094	.0006	N/A
840151	0	NONE	3-08-84	9885.0	N/A	22.8	0.322	3.743	173.800	0.218	0.3191	.0029	N/A

Emissions Data Generated During 30 MPH Steady State Operation

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-5Pt:Rh(40)			**(STOCK)**	**0% O2**									
814215	0	STOCK	6-29-82	2685.0	1.4	21.7	0.004	0.062	189.231	0.002	0.005	-.0010	0.009
814218	0	STOCK	6-30-82	2739.4	0.4	21.7	0.005	0.057	189.665	0.0	0.002	.0030	0.003
814221	0	STOCK	7-01-82	2810.0	2.4	20.9	0.006	0.069	197.007	0.007	0.004	.0020	0.009
814224	0	STOCK	7-02-82	2860.0	2.8	21.1	0.006	0.058	194.629	0.0	0.002	.0040	0.001
NO CATALYST				**0% O2**									
815242	0	NONE	8-13-82	3184.0	169.3	21.2	0.363	4.387	186.507	1.212	0.362	.0010	0.897
815245	0	NONE	8-17-82	3213.0	166.5	21.3	0.349	4.393	184.963	1.300	0.348	.0010	0.773
815247	0	NONE	8-17-82	3235.0	159.6	21.4	0.340	4.622	183.618	1.188	0.339	.0010	0.788
NO CATALYST				**3% O2**									
815253	3	NONE	8-20-82	3340.0	142.1	21.8	0.327	4.296	181.356	1.147	0.326	.0010	0.848
815256	3	NONE	8-25-82	3396.0	141.3	20.6	0.336	4.122	192.444	1.242	N/A	N/A	0.924
815259	3	NONE	8-26-82	3425.0	104.0	21.5	0.314	4.184	184.098	1.200	N/A	N/A	0.897
NO CATALYST				**5% O2**									
815267	5	NONE	9-10-82	3595.5	107.1	21.2	0.319	4.447	185.846	1.158	N/A	N/A	0.930
815269	5	NONE	9-10-82	3625.0	108.2	21.0	0.321	4.519	187.998	1.211	N/A	N/A	0.898
815271	5	NONE	9-14-82	3662.0	130.6	21.2	0.323	4.201	186.415	1.174	N/A	N/A	0.910
4x6-12Pt:Rh(40)			**(#1)**	**0% O2**									
816032	0	(#1)	9-16-82	3747.0	0.3	21.6	0.002	0.017	190.880	0.002	0.001	.0010	0.002
815994	0	(#1)	9-21-82	3828.0	0.4	21.5	0.003	0.028	191.718	0.005	0.002	.0010	0.008
4x6-12Pt:Rh(40)			**(#1)**	**3% O2**									
816002	3	(#1)	9-29-82	3983.0	0.90	21.5	0.008	0.001	191.581	1.140	0.004	.0040	0.002
4x6-12Pt:Rh(40)			**(#1)**	**5% O2**									
816008	5	(#1)	10-01-82	4065.0	0.6	21.4	0.008	0.0	192.321	1.174	0.005	.0030	0.003
816010	5	(#1)	10-01-82	4100.0	2.2	21.2	0.008	0.0	194.049	1.262	0.004	.0040	N/A
4x6-12Pt:Rh(40)			**(#1)**	**3% O2**	**(AGAIN)**								
816017	3	(#1)	10-08-82	4229.9	2.7	21.2	0.008	0.0	194.449	1.215	0.005	.0030	0.005
816019	3	(#1)	10-08-82	4236.5	3.0	21.6	0.009	0.0	190.452	1.210	0.006	.0030	0.004
NO CATALYST				**0% O2**									
816025	0	NONE	10-14-82	4353.0	110.4	21.3	0.336	4.265	185.561	1.260	0.334	.0020	0.873
6xRTO-12Pt:Rh(40)			**(#2)**	**0% O2**									
816563	0	(#2)	10-19-82	4450.0	0.5	21.7	0.006	0.0	189.783	0.395	0.004	.0020	0.024
816571	0	(#2)	11-02-82	4625.0	6.7	21.0	0.007	0.023	196.256	0.562	0.005	.0020	N/A

Emissions Data Generated During 30 MPH Steady State Operation (Continued)

Test Number	02 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
6xRTO-12Pt:Rh(40) (#2)				**5% 02**									
816579	5	(#2)	11-05-82	4768.0	5.6	20.3	0.010	0.029	203.143	1.218	0.007	.0030	0.052
NO CAT CHECK OUT				**5% 02**									
816585+	5	NONE	11-19-82	4888.0	N/A	17.1	0.138	4.214	233.636	0.385	0.133	.0050	N/A
NO CATALYST				**0% 02**									
816599	0	NONE	12-07-82	5140.0	104.9	20.4	0.354	4.752	192.987	1.156	0.351	.0030	N/A
816603	0	NONE	12-08-82	5192.0	109.8	20.9	0.341	4.967	188.026	1.182	0.338	.0030	N/A
4x6-3Pt:2Pd(20) (#3)				**0% 02**									
816611	0	(#3)	12-14-82	5321.0	N/A	21.0	0.006	0.189	195.774	0.027	N/A	N/A	N/A
816613	0	(#3)	12-15-82	5343.0	N/A	20.2	0.013	0.250	203.138	0.061	0.009	.0040	N/A
4x6-3Pt:2Pd(20) (#3)				**3% 02**									
816616	3	(#3)	12-16-82	5403.0	N/A	20.2	0.017	0.0	204.257	1.277	0.014	.0030	N/A
816620	3	(#3)	12-17-82	5454.0	N/A	19.4	0.058	0.034	211.459	1.194	0.055	.0030	0.168
817461	3	(#3)	12-21-82	5504.0	70.74	20.0	0.033	0.006	206.135	1.219	0.029	.0040	0.042
4x6-3Pt:2Pd(20) (#3)				**5% 02**									
817467	5	(#3)	1-04-83	5599.6	98.95	19.6	0.100	0.123	209.362	1.224	N/A	N/A	N/A
817469	5	(#3)	1-04-83	5612.0	114.98	20.8	0.024	0.006	198.279	1.088	N/A	N/A	N/A
NO CATALYST				**0% 02**									
817473	0	NONE	1-05-83	5668.0	72.28	19.8	0.415	5.372	198.553	1.306	N/A	N/A	N/A
4x6-Pd(40) (#4)				**0% 02**									
817475	0	(#4)	1-06-83	5680.0	3.28	20.4	0.014	0.475	201.469	0.005	N/A	N/A	0.036
817483	0	(#4)	1-12-83	5808.0	3.78	20.2	0.013	0.627	202.518	0.010	0.010	.0030	N/A
4x6-Pd(40) (#4)				**3% 02**									
817487	3	(#4)	1-13-83	5869.0	21.6	20.4	0.010	0.006	201.947	1.026	0.006	.0040	N/A
817491	3	(#4)	1-14-83	5921.0	14.8	20.7	0.009	0.006	199.129	1.083	0.006	.0030	N/A
4x6-Pd(40) (#4)				**5% 02**									
817494	5	(#4)	1-18-83	5968.4	22.9	20.7	0.011	0.007	198.854	1.073	0.007	.0040	N/A
817498+	5	(#4)	1-19-83	6020.0	41.4	19.7	0.013	0.018	209.224	1.179	0.010	.0030	N/A
NO CATALYST				**0% 02**									
817924	0	NONE	1-27-83	6118.0	121.95	N/A	0.387	6.004	N/A	1.088	0.384	.0030	N/A
4x6-Pd+Base Metal(35) (#5)				**0% 02**									
817928+	0	(#5)	1-28-83	6172.0	N/A	N/A	0.064	3.635	N/A	0.973	0.063	.0010	N/A
817932+	0	(#5)	2-01-83	6225.0	N/A	N/A	0.080	3.620	N/A	1.053	0.078	.0020	N/A

Emissions Data Generated During 30 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Pd+Base Metal(35) (#5)				**3% O2**									
817936+	3	(#5)	2-02-83	6282.0	N/A	20.7	0.097	3.659	192.641	1.125	0.095	.0020	N/A
4x6-Pd+Base Metal(35) (#5)				**0% O2**									
817942	0	(#5)	2-09-83	6428.0	38.05	21.5	0.066	2.199	187.403	1.109	0.063	.0030	N/A
817946+	0	(#5)	2-10-83	6481.0	47.53	N/A	0.072	2.548	N/A	1.126	0.069	.0030	N/A
4x6-Pd+Base Metal(35) (#5)				**3% O2**									
817950+	3	(#5)	2-11-83	6535.0	N/A	N/A	0.125	3.246	N/A	1.057	0.122	.0030	N/A
817954	3	(#5)	2-15-83	6591.0	N/A	21.2	0.137	3.977	187.662	1.067	0.132	.0050	N/A
4x6-Pd+Base Metal(35) (#5)				**5% O2**									
818395	5	(#5)	2-17-83	6688.0	N/A	20.9	0.258	4.576	188.833	1.094	0.254	.0040	N/A
818399	5	(#5)	2-18-83	6743.0	N/A	21.5	0.252	4.470	184.026	1.056	0.247	.0050	N/A
4x6-Cu Mesh (#6)				**0% O2**									
818407	0	(#6)	2-24-83	6874.0	N/A	21.2	0.394	4.871	185.177	1.113	0.390	.0040	N/A
818411	0	(#6)	2-25-83	6930.0	N/A	20.9	0.403	5.220	187.372	1.119	0.397	.0060	N/A
4x6-Cu Mesh (#6)				**3% O2**									
818415	3	(#6)	3-01-83	7000.0	N/A	21.0	0.408	4.342	188.013	1.107	0.405	.0030	N/A
818647	3	(#6)	3-02-83	7053.2	N/A	20.8	0.412	5.056	189.016	1.119	0.408	.0040	N/A
4x6-Cu Mesh (#6)				**5% O2**									
818651	5	(#6)	3-03-83	7108.8	N/A	21.3	0.288	3.456	186.539	0.816	0.285	.0030	N/A
818655	5	(#6)	3-04-83	7159.1	N/A	20.5	0.375	4.370	192.543	1.113	0.368	.0070	N/A
4x6-Pd(20) (#7)				**0% O2**									
818663	0	(#7)	3-10-83	7294.7	N/A	20.8	0.018	1.332	195.359	0.015	0.013	.0050	N/A
818667	0	(#7)	3-11-83	7348.0	N/A	20.7	0.012	0.862	197.413	0.030	0.007	.0050	N/A
818724	0	(#7)	3-15-83	7399.0	N/A	20.9	0.009	1.184	195.432	0.010	0.004	.0050	N/A
4x6-Pd(20) (#7)				**3% O2**									
818728	3	(#7)	3-16-83	7454.0	N/A	21.4	0.009	-0.004	192.800	1.018	0.005	.0040	N/A
818732	3	(#7)	3-17-83	7506.0	N/A	21.0	0.008	0.007	195.931	1.012	0.004	.0040	N/A
4x6-Pd(20) (#7)				**5% O2**									
818736	5	(#7)	3-18-83	7563.0	N/A	21.4	0.009	0.011	192.34	1.018	0.005	.0040	N/A
818740	5	(#7)	3-22-83	7614.0	N/A	21.1	0.009	0.006	195.22	1.074	N/A	N/A	N/A
818977	5	(#7)	3-23-83	7666.0	N/A	21.0	0.009	-.004	196.370	1.111	N/A	N/A	N/A
4x6-Ag(150) (#8)				**0% O2**									
818993	0	(#8)	4-07-83	7974.8	N/A	21.9	0.221	4.090	180.868	0.971	0.217	.0040	N/A
818997	0	(#8)	4-08-83	8026.0	N/A	20.9	0.233	4.086	189.955	1.108	0.2287	.0043	N/A

Emissions Data Generated During 30 MPH Steady State Operation (Continued)

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-Ag(150) (#8)				**3% O2**									
819244	3	(#8)	4-21-83	8259.0	N/A	21.9	0.134	4.383	181.073	0.967	0.1295	.0045	N/A
819248	3	(#8)	4-22-83	8392.0	N/A	22.0	0.121	4.898	178.946	0.908	N/A	N/A	N/A
4x6-Ag(150) (#8)				**5% O2**									
819257	5	(#8)	4-29-83	8464.0	N/A	20.7	0.223	5.213	190.038	1.033	0.2181	.0049	N/A
819261	5	(#8)	5-04-83	8501.5	N/A	21.4	0.281	4.745	183.646	1.065	0.2768	.0042	N/A
NO CATALYST				**0% O2**									
819276	0	NONE	5-24-83	8767.0	N/A	23.4	0.339	5.207	166.352	0.723	0.3343	.0047	N/A
819282	0	NONE	5-25-83	8820.0	N/A	21.1	0.387	5.283	185.969	1.106	N/A	N/A	N/A
820327	0	NONE	5-26-83	8871.0	N/A	21.1	0.380	5.240	185.948	1.115	0.3752	.0048	N/A
820379	0	NONE	7-06-83	8991.0	N/A	24.1	0.307	3.706	164.007	0.783	0.3032	.0038	N/A
820384	0	NONE	7-07-83	9030.0	N/A	23.4	0.345	3.734	169.336	0.811	0.3405	.0045	N/A
4x6-Cu - Acid Dipped (#9)				**3% O2**									
840125	3	(#9)	11-08-83	9560.0	N/A	21.2	0.334	3.520	187.403	1.132	0.3306	.0034	N/A
840131	3	(#9)	11-09-83	9605.0	N/A	21.3	0.331	3.450	186.625	1.113	0.3270	.0040	N/A
840137	3	(#9)	11-10-83	9655.0	N/A	21.7	0.319	3.277	183.436	1.050	N/A	N/A	N/A
NO CATALYST				**0% O2**									
840142	0	NONE	2-14-84	9783.0	N/A	23.6	0.425	3.547	167.660	0.843	0.4237	.0013	N/A
840147	0	NONE	2-15-84	9835.0	N/A	23.8	0.371	3.483	166.703	0.823	0.3704	.0006	N/A
840152	0	NONE	3-08-84	9889.0	N/A	24.6	0.341	3.636	160.551	0.749	0.3390	.0020	N/A

Emissions Data Generated During 40 MPH Steady State Operation

Test Number	O2 %	CAT#	Test Date	ODOM (mi)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)	METHANOL (g/mi)
4x6-5Pt:Rh(40)			**(STOCK)**	**0% O2**									
814215	0	STOCK	6-29-82	2685.0	0.5	21.5	0.002	0.016	191.641	0.032	0.002	.0000	0.002
814218	0	STOCK	6-30-82	2739.4	0.00	20.0	0.002	0.0	206.162	0.256	0.000	.0020	0.001
814221	0	STOCK	7-01-82	2810.0	0.64	20.8	0.001	0.028	198.055	0.055	0.002	-.0010	0.001
814224	0	STOCK	7-02-82	2860.0	0.54	20.8	0.003	0.036	198.112	0.015	0.003	.0000	0.002
NO CATALYST				**0% O2**									
815243+	0	NONE	8-13-82	3192.0	197.7	18.7	0.381	4.229	212.537	1.843	0.381	.0000	1.024
815245	0	NONE	8-17-82	3213.0	170.5	21.6	0.309	3.813	183.906	1.583	0.308	.0010	0.722
815247	0	NONE	8-17-82	3235.0	166.3	19.5	0.329	4.076	203.190	1.698	0.328	.0010	0.926
NO CATALYST				**3% O2**									
815253	3	NONE	8-20-82	3340.0	150.9	20.6	0.290	4.245	192.367	1.601	0.289	.0010	0.774
815256	3	NONE	8-25-82	3396.0	N/A	20.1	0.289	4.082	197.967	1.693	N/A	N/A	0.828
815259	3	NONE	8-26-82	3425.0	119.9	19.8	0.299	3.865	201.364	1.639	N/A	N/A	0.947
NO CATALYST				**5% O2**									
815267	5	NONE	9-10-82	3595.5	113.5	19.4	0.307	3.895	205.590	1.761	N/A	N/A	0.789
815269	5	NONE	9-10-82	3625.0	117.4	20.0	0.283	3.969	198.963	1.695	N/A	N/A	0.743
815271	5	NONE	9-14-82	3662.0	119.6	20.2	0.291	4.074	196.239	1.627	N/A	N/A	0.891

Testing over the 40 MPH Steady State driving cycle was terminated on 9-14-82.

APPENDIX 5

Statistics with the Data
Stratified by Oxygen Level,
Test Cycle, and Individual Catalyst

Emission Statistics for FTP Driving Cycle
For Catalyst: 12Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	8.5400	13.180	11.623	2.6703
MPG	3	13.886	14.011	13.968	.07047
HC	3	.10050	.12220	.11073	.01090
CO	3	.41600	.93400	.69267	.26080
CO2	3	292.29	295.34	293.70	1.5380
NOx	3	.49670	.70000	.62110	.10902
Non-Methane HC	2	.10420	.11590	.11005	.00827
Methane	2	.00530	.00630	.00580	.00071
Methanol	2	.30400	.35300	.32850	.03465

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	12.880	17.530	15.590	2.4187
MPG	3	13.624	14.556	14.016	.48354
HC	3	.11310	.12810	.11870	.00819
CO	3	.31300	.50300	.38733	.10152
CO2	3	282.42	300.62	293.07	9.4861
NOx	3	1.8790	2.0981	2.0062	.11372
Non-Methane HC	3	.10620	.12270	.11277	.00875
Methane	3	.00540	.00690	.00593	.00084
Methanol	3	.29100	.31600	.30667	.01365

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	18.940	22.100	20.985	1.4677
MPG	4	13.762	14.107	13.910	.15415
HC	4	.10820	.13830	.12435	.01253
CO	4	.32300	.48100	.39875	.06635
CO2	4	290.77	297.66	294.70	3.1739
NOx	2	2.0731	2.1175	2.0953	.03140
Non-Methane HC	4	.10350	.13150	.11892	.01172
Methane	4	.00470	.00680	.00542	.00094
Methanol	4	.26900	.37500	.31700	.04393

Emission Statistics for FTP Driving Cycle
For Catalyst: 12Pt:Rh(40) - Racetrack

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	9.9000	13.000	11.450	2.1920
MPG	2	13.826	14.078	13.952	.17847
HC	2	.11170	.14940	.13055	.02666
CO	2	.70300	.84000	.77150	.09687
CO2	2	291.36	296.29	293.82	3.4860
NOx	2	.75530	.76720	.76125	.00841
Non-Methane HC	1	.14440	.14440	.14440	
Methane	1	.00500	.00500	.00500	
Methanol	1	.82000	.82000	.82000	

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	13.350	15.140	14.453	.96500
MPG	3	13.672	13.827	13.737	.08062
HC	3	.11990	.13490	.12837	.00768
CO	3	.23500	.50800	.40300	.14700
CO2	3	296.99	299.66	298.41	1.3431
NOx	3	2.0242	2.0682	2.0455	.02203
Non-Methane HC	3	.11530	.12990	.12380	.00759
Methane	3	.00410	.00500	.00457	.00045
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	20.810	20.810	20.810	
MPG	1	13.763	13.763	13.763	
HC	1	.13130	.13130	.13130	
CO	1	.45900	.45900	.45900	
CO2	1	298.39	298.39	298.39	
NOx	1	2.0939	2.0939	2.0939	
Non-Methane HC	1	.12620	.12620	.12620	
Methane	1	.00510	.00510	.00510	
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	29.520	36.390	32.955	4.8578
MPG	3	13.648	13.879	13.780	.11874
HC	3	.14620	.16070	.15443	.00745
CO	3	1.3570	1.6460	1.4673	.15615
CO2	3	294.13	299.37	296.13	2.8294
NOx	3	.83930	.87030	.85300	.01581
Non-Methane HC	2	.14240	.15490	.14865	.00884
Methane	2	.00380	.00580	.00480	.00141
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	72.940	72.940	72.940	
MPG	2	13.365	13.496	13.430	.09270
HC	2	.15660	.16360	.16010	.00495
CO	2	.34500	.35500	.35000	.00707
CO2	2	304.36	307.12	305.74	1.9516
NOx	2	2.0517	2.0855	2.0686	.02390
Non-Methane HC	2	.15070	.15620	.15345	.00389
Methane	2	.00590	.00740	.00665	.00106
Methanol	2	.21200	.34000	.27600	.09051

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	117.30	117.40	117.35	.07071
MPG	2	13.485	13.538	13.511	.03755
HC	2	.18100	.19940	.19020	.01301
CO	2	.34900	.44000	.39450	.06435
CO2	2	302.97	303.84	303.40	.61518
NOx	2	1.9743	2.0929	2.0336	.08386
Non-Methane HC	1	.19300	.19300	.19300	
Methane	1	.00640	.00640	.00640	
Methanol	2	.29600	.42300	.35950	.08980

Emission Statistics for FTP Driving Cycle
For Catalyst: Pd(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	38.550	46.900	41.547	4.6472
MPG	3	13.412	13.552	13.470	.07314
HC	3	.15330	.19020	.16903	.01904
CO	3	1.5870	2.2850	1.9863	.35972
CO2	3	299.86	304.39	301.96	2.2837
NOx	3	.72610	.75480	.74293	.01498
Non-Methane HC	2	.14920	.15770	.15345	.00601
Methane	2	.00410	.00590	.00500	.00127
Methanol	2	.33900	.35200	.34550	.00919

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	59.330	76.650	67.990	12.247
MPG	2	13.367	13.495	13.431	.09072
HC	2	.13840	.15140	.14490	.00919
CO	2	.36500	.39300	.37900	.01980
CO2	2	304.12	307.43	305.77	2.3405
NOx	2	1.9570	2.0082	1.9826	.03620
Non-Methane HC	2	.13400	.14680	.14040	.00905
Methane	2	.00440	.00460	.00450	.00014
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	111.29	172.67	141.87	30.691
MPG	3	13.227	13.324	13.264	.05247
HC	3	.15100	.17540	.15983	.01352
CO	3	.28600	.45700	.35600	.08962
CO2	3	308.29	310.47	309.57	1.1403
NOx	3	1.9532	2.1090	2.0516	.08563
Non-Methane HC	3	.14530	.17010	.15453	.01356
Methane	3	.00490	.00570	.00530	.00040
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: Pd + Base Metal(35)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	118.46	119.24	118.85	.55154
MPG	1	14.141	14.141	14.141	
HC	2	.27670	.27700	.27685	.00021
CO	2	2.7230	2.9780	2.8505	.18031
CO2	1	285.53	285.53	285.53	
NOx	2	1.9502	1.9934	1.9718	.03055
Non-Methane HC	2	.26960	.27040	.27000	.00057
Methane	2	.00660	.00710	.00685	.00035
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	117.52	141.23	129.37	16.766
MPG	1	13.895	13.895	13.895	
HC	2	.27490	.28110	.27800	.00438
CO	2	1.9380	2.1650	2.0515	.16051
CO2	1	291.97	291.97	291.97	
NOx	2	1.8986	2.0035	1.9510	.07418
Non-Methane HC	2	.26680	.27440	.27060	.00537
Methane	2	.00670	.00810	.00740	.00099
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	253.12	304.58	279.53	25.757
MPG	3	13.749	13.914	13.852	.08985
HC	3	.35840	.37090	.36663	.00713
CO	3	3.3620	3.9330	3.6547	.28577
CO2	3	289.16	293.02	290.48	2.1975
NOx	3	1.9139	1.9529	1.9378	.02094
Non-Methane HC	3	.35200	.36400	.35940	.00647
Methane	3	.00640	.00870	.00723	.00127
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	268.82	315.03	291.92	32.675
MPG	2	13.663	13.724	13.693	.04328
HC	2	.90070	.90530	.90300	.00325
CO	2	7.3100	7.7200	7.5150	.28991
CO2	2	285.38	286.85	286.11	1.0394
NOx	2	1.8650	1.9046	1.8848	.02800
Non-Methane HC	2	.89320	.89700	.89510	.00269
Methane	2	.00750	.00830	.00790	.00057
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	312.47	332.15	322.31	13.916
MPG	2	13.433	13.449	13.441	.01124
HC	2	.88460	.92010	.90235	.02510
CO	2	7.2140	7.3710	7.2925	.11102
CO2	2	291.51	291.94	291.72	.30406
NOx	2	1.8147	1.8197	1.8172	.00354
Non-Methane HC	2	.87840	.91380	.89610	.02503
Methane	2	.00620	.00630	.00625	.00007
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	303.13	324.61	313.87	15.189
MPG	2	13.435	13.506	13.471	.05013
HC	2	.83240	.90550	.86895	.05169
CO	2	6.8820	6.9830	6.9325	.07142
CO2	2	291.39	293.39	292.39	1.4142
NOx	2	1.8135	1.8320	1.8227	.01308
Non-Methane HC	2	.82560	.89770	.86165	.05098
Methane	2	.00680	.00780	.00730	.00071
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	35.350	48.630	41.030	6.8450
MPG	3	13.682	13.915	13.810	.11846
HC	3	.16680	.20080	.18483	.01709
CO	3	1.4910	2.0940	1.8387	.31192
CO2	3	292.75	296.69	294.61	1.9786
NOx	3	.62510	.70290	.66630	.03910
Non-Methane HC	3	.16210	.19340	.17787	.01565
Methane	3	.00470	.00880	.00697	.00208
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	88.670	99.720	94.195	7.8135
MPG	2	13.766	13.904	13.835	.09765
HC	2	.14590	.15980	.15285	.00983
CO	2	.39400	.40400	.39900	.00707
CO2	2	294.71	297.97	296.34	2.3052
NOx	2	1.8527	1.9380	1.8953	.06032
Non-Methane HC	2	.14030	.15260	.14645	.00870
Methane	2	.00560	.00720	.00640	.00113
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	102.16	105.82	103.99	2.5880
MPG	2	13.638	13.772	13.705	.09412
HC	2	.12880	.14000	.13440	.00792
CO	2	.29900	.32600	.31250	.01909
CO2	2	298.28	301.38	299.83	2.1920
NOx	2	1.9065	1.9085	1.9075	.00141
Non-Methane HC	0				
Methane	0				
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: Silver (Ag)(150)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	41.800	70.970	59.317	12.762
MPG	4	13.765	14.038	13.853	.12764
HC	4	.44600	.61130	.53957	.06870
CO	4	6.2910	6.6850	6.5245	.16915
CO2	4	281.64	287.39	285.20	2.6340
NOx	4	2.0083	2.0506	2.0282	.01845
Non-Methane HC	4	.43990	.60320	.53247	.06791
Methane	4	.00610	.00810	.00710	.00082
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	34.670	71.040	51.963	18.250
MPG	3	13.601	13.877	13.709	.14700
HC	3	.35270	.47810	.42800	.06639
CO	3	5.4730	6.4770	5.9310	.50775
CO2	3	284.98	292.53	289.65	4.0831
NOx	3	1.9775	2.0052	1.9892	.01436
Non-Methane HC	2	.44500	.47130	.45815	.01860
Methane	2	.00680	.00820	.00750	.00099
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	73.800	102.05	86.950	14.226
MPG	3	13.538	13.918	13.747	.19293
HC	3	.54180	.62470	.58603	.04173
CO	3	6.8990	7.1620	7.0077	.13732
CO2	3	283.19	291.46	286.72	4.2671
NOx	3	1.8919	2.0046	1.9538	.05717
Non-Methane HC	3	.53460	.61670	.57857	.04136
Methane	3	.00720	.00800	.00747	.00046
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: Acid Dipped Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	5	405.88	453.85	425.77	20.619
MPG	5	14.518	15.536	14.832	.40339
HC	5	.70140	.88270	.79434	.07819
CO	5	5.5890	6.0000	5.8764	.16398
CO2	5	254.25	272.16	266.14	6.8986
NOx	5	1.6340	1.8118	1.7562	.07274
Non-Methane HC	5	.69360	.87430	.78638	.07786
Methane	5	.00740	.00840	.00796	.00040
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	395.50	562.94	460.73	89.636
MPG	3	13.682	13.871	13.761	.09834
HC	3	.91840	.94570	.93243	.01367
CO	3	6.2500	6.3660	6.3130	.05864
CO2	3	284.44	287.54	286.37	1.6817
NOx	3	1.9624	2.0106	1.9900	.02485
Non-Methane HC	3	.91050	.93660	.92347	.01305
Methane	3	.00790	.00990	.00897	.00101
Methanol	0				

Emission Statistics for FTP Driving Cycle
For Catalyst: Pd + Base Metal(5)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	15.262	15.391	15.314	.06866
HC	3	.19320	.19630	.19427	.00176
CO	3	1.0760	1.3660	1.2123	.14577
CO2	3	264.65	267.24	266.13	1.3355
NOx	3	.81750	.84520	.83007	.01403
Non-Methane HC	3	.18550	.19130	.18893	.00304
Methane	3	.00190	.00780	.00533	.00307
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	14.275	14.570	14.459	.16028
HC	3	.17560	.19510	.18283	.01068
CO	3	.49000	.65000	.54867	.08812
CO2	3	280.56	287.14	283.23	3.4608
NOx	3	1.7603	1.8869	1.8046	.07137
Non-Methane HC	3	.16840	.18710	.17507	.01044
Methane	3	.00720	.00810	.00777	.00049
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	1	14.306	14.306	14.306	
HC	1	.21590	.21590	.21590	
CO	1	.69600	.69600	.69600	
CO2	1	286.06	286.06	286.06	
NOx	1	1.8386	1.8386	1.8386	
Non-Methane HC	1	.20680	.20680	.20680	
Methane	1	.00910	.00910	.00910	
Methanol	0				

Emission Statistics for FTP Driving Cycle For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	25	111.73	325.72	228.26	51.270
MPG	28	13.399	15.874	14.295	.59228
HC	29	.78480	1.4519	1.0127	.13924
CO	29	6.0270	9.1200	7.3862	.69937
CO2	28	243.95	292.91	273.71	11.994
NOx	29	1.5026	2.2062	1.9560	.18426
Non-Methane HC	24	.78040	1.4475	1.0195	.14558
Methane	24	.00060	.00970	.00610	.00243
Methanol	4	1.7830	2.4530	2.1767	.28197

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	5	219.32	281.30	247.01	26.029
MPG	5	13.686	14.068	13.934	.15061
HC	5	.78950	1.0762	.91690	.14370
CO	5	7.1570	7.3910	7.2546	.09183
CO2	5	278.22	286.13	281.45	2.9906
NOx	5	2.0030	2.1688	2.0925	.05901
Non-Methane HC	3	.78850	.85150	.81280	.03388
Methane	3	0.	.00100	.00067	.00058
Methanol	3	2.0180	2.1350	2.0820	.05927

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	6	185.00	233.69	206.94	20.894
MPG	6	13.464	13.957	13.826	.18513
HC	6	.76750	1.1244	.90380	.14992
CO	6	7.2400	7.9500	7.5133	.28073
CO2	6	280.11	291.15	283.20	4.0980
NOx	6	1.9903	2.1911	2.0887	.06531
Non-Methane HC	2	.83150	1.1164	.97395	.20145
Methane	2	.00490	.00800	.00645	.00219
Methanol	3	2.4130	2.5300	2.4617	.06093

Emission Statistics for FTP Driving Cycle
For Catalyst: 5Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	17.180	26.260	20.257	4.2232
MPG	6	13.922	14.725	14.183	.27826
HC	6	.13560	.19020	.15465	.01909
CO	6	.69500	.90000	.78350	.08260
CO2	6	278.49	294.50	288.89	5.4259
NOx	4	.53040	1.6792	.83737	.56187
Non-Methane HC	2	.13980	.14650	.14315	.00474
Methane	2	.00290	.00310	.00300	.00014
Methanol	4	.14200	.30300	.20550	.07042

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	15.370	15.370	15.370	
MPG	1	13.752	13.752	13.752	
HC	1	.14310	.14310	.14310	
CO	1	.60300	.60300	.60300	
CO2	1	297.79	297.79	297.79	
NOx	1	1.9496	1.9496	1.9496	
Non-Methane HC	1	.13600	.13600	.13600	
Methane	1	.00710	.00710	.00710	
Methanol	1	.58700	.58700	.58700	

Emission Statistics for HWY Driving Cycle
For Catalyst: 12Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	.30000	1.0000	.53333	.40415
MPG	3	17.219	17.439	17.318	.11160
HC	3	.00300	.00410	.00337	.00064
CO	3	.02600	.06400	.04800	.01970
CO2	3	235.59	239.04	237.61	1.8007
NOx	3	.58040	.63290	.61050	.02708
Non-Methane HC	3	.00270	.00380	.00317	.00057
Methane	3	0.	.00030	.00020	.00017
Methanol	2	.00600	.01200	.00900	.00424

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	1.0000	1.6000	1.2333	.32146
MPG	3	17.081	18.712	17.745	.85690
HC	3	.00810	.00940	.00863	.00068
CO	3	0.	.00800	.00433	.00404
CO2	3	219.54	240.80	232.08	11.135
NOx	3	2.4257	2.8921	2.7338	.26688
Non-Methane HC	3	.00590	.00690	.00653	.00055
Methane	3	.00160	.00250	.00210	.00046
Methanol	3	.00400	.00500	.00433	.00058

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	1.7000	2.2000	1.9250	.20616
MPG	4	17.223	17.517	17.389	.12546
HC	4	.00770	.01140	.00965	.00152
CO	4	0.	.00700	.00200	.00337
CO2	4	234.86	239.10	236.66	1.7868
NOx	3	2.7040	2.9207	2.7820	.12045
Non-Methane HC	4	.00480	.00800	.00672	.00136
Methane	4	.00260	.00340	.00292	.00034
Methanol	4	.00400	.00900	.00600	.00216

Emission Statistics for HWY Driving Cycle
For Catalyst: 12Pt:Rh(40) - Racetrack

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	.80000	1.6000	1.1667	.40415
MPG	3	17.147	18.046	17.721	.49843
HC	3	.00500	.01290	.00830	.00411
CO	3	.05700	.06700	.06233	.00503
CO2	3	228.40	239.52	232.43	6.1568
NOx	3	.47520	.69750	.55043	.12737
Non-Methane HC	2	.00460	.01260	.00860	.00566
Methane	2	.00030	.00040	.00035	.00007
Methanol	2	.00400	.06500	.03450	.04313

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	1.6000	2.3000	2.0333	.37859
MPG	3	17.295	17.442	17.368	.07341
HC	3	.00820	.00930	.00873	.00055
CO	3	.02300	.02700	.02467	.00208
CO2	3	236.36	237.75	237.16	.71988
NOx	3	2.8026	2.8602	2.8384	.03127
Non-Methane HC	3	.00720	.00800	.00750	.00044
Methane	3	.00100	.00140	.00123	.00021
Methanol	3	.00900	.02300	.01400	.00781

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	2.2000	2.2000	2.2000	
MPG	1	17.366	17.366	17.366	
HC	1	.00980	.00980	.00980	
CO	1	.02800	.02800	.02800	
CO2	1	237.17	237.17	237.17	
NOx	1	2.7982	2.7982	2.7982	
Non-Methane HC	1	.00830	.00830	.00830	
Methane	1	.00150	.00150	.00150	
Methanol	1	.02700	.02700	.02700	

Emission Statistics for HWY Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.91000	1.1700	1.0400	.18385
MPG	3	16.919	17.344	17.155	.21603
HC	3	.00610	.00900	.00733	.00150
CO	3	.19800	.23100	.21600	.01670
CO2	3	237.26	243.41	239.95	3.1465
NOx	3	.62550	.64780	.63983	.01244
Non-Methane HC	2	.00520	.00790	.00655	.00191
Methane	2	.00090	.00110	.00100	.00014
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	1.7000	1.7000	1.7000	
MPG	3	16.803	17.079	16.918	.14392
HC	3	.00950	.01000	.00980	.00026
CO	3	0.	.01700	.00567	.00982
CO2	3	241.17	244.82	243.39	1.9511
NOx	3	2.7388	2.8118	2.7695	.03784
Non-Methane HC	3	.00600	.00710	.00653	.00055
Methane	3	.00280	.00350	.00327	.00040
Methanol	2	.01100	.01600	.01350	.00354

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	2.9300	3.0400	2.9850	.07778
MPG	2	17.011	17.081	17.046	.04928
HC	2	.00920	.01000	.00960	.00057
CO	2	0.	.00700	.00350	.00495
CO2	2	241.45	242.24	241.84	.55861
NOx	2	2.7420	2.8272	2.7846	.06024
Non-Methane HC	2	.00600	.00650	.00625	.00035
Methane	2	.00320	.00350	.00335	.00021
Methanol	2	.00900	.00900	.00900	

Emission Statistics for HWY Driving Cycle
For Catalyst: Pd(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	.36000	1.1000	.72333	.37018
MPG	3	16.909	17.044	16.976	.06745
HC	3	.00430	.00640	.00550	.00108
CO	3	.29800	.34500	.32567	.02458
CO2	3	241.29	242.81	242.09	.76370
NOx	3	.42810	.57360	.50747	.07365
Non-Methane HC	2	.00520	.00550	.00535	.00021
Methane	2	.00060	.00090	.00075	.00021
Methanol	2	.00800	.02400	.01600	.01131

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	1.6700	1.9000	1.7850	.16263
MPG	2	17.010	17.081	17.046	.05020
HC	2	.00730	.00900	.00815	.00120
CO	2	.00800	.01400	.01100	.00424
CO2	2	240.64	241.56	241.10	.65054
NOx	2	2.6469	2.6516	2.6492	.00332
Non-Methane HC	2	.00470	.00720	.00595	.00177
Methane	2	.00180	.00260	.00220	.00057
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	2.6500	2.8000	2.7250	.10607
MPG	2	16.940	17.081	17.010	.09942
HC	2	.00860	.00940	.00900	.00057
CO	2	.01000	.01400	.01200	.00283
CO2	2	241.35	243.15	242.25	1.2728
NOx	2	2.7164	2.7267	2.7215	.00728
Non-Methane HC	2	.00570	.00650	.00610	.00057
Methane	2	.00290	.00290	.00290	
Methanol	0				

Emission Statistics for HWY Driving Cycle
For Catalyst: Pd + Base Metal(35)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	2.6400	3.5900	3.1150	.67175
MPG	1	17.588	17.588	17.588	
HC	2	.01500	.01660	.01580	.00113
CO	2	1.3040	1.6600	1.4820	.25173
CO2	1	232.45	232.45	232.45	
NOx	2	1.5459	1.7229	1.6344	.12516
Non-Methane HC	2	.01100	.01200	.01150	.00071
Methane	2	.00400	.00460	.00430	.00042
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	2.7600	3.2000	2.9800	.31113
MPG	1	17.510	17.510	17.510	
HC	2	.01320	.01320	.01320	
CO	2	.03000	.06000	.04500	.02121
CO2	1	234.96	234.96	234.96	
NOx	2	2.5670	2.6360	2.6015	.04879
Non-Methane HC	2	.00920	.00930	.00925	.00007
Methane	2	.00390	.00400	.00395	.00007
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	11.480	17.460	14.470	4.2285
MPG	2	17.553	17.836	17.695	.20039
HC	2	.01330	.01460	.01395	.00092
CO	2	.32900	.50400	.41650	.12374
CO2	2	230.27	233.66	231.96	2.3971
NOx	2	2.6354	2.6455	2.6404	.00714
Non-Methane HC	2	.00890	.01000	.00945	.00078
Methane	2	.00440	.00460	.00450	.00014
Methanol	0				

Emission Statistics for HWY Driving Cycle
For Catalyst: Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	125.11	136.31	130.71	7.9196
MPG	2	16.699	17.365	17.032	.47065
HC	2	.26170	.34630	.30400	.05982
CO	2	6.8240	6.9950	6.9095	.12092
CO2	2	225.36	234.83	230.09	6.6963
NOx	2	2.3906	2.4293	2.4099	.02736
Non-Methane HC	2	.25610	.34080	.29845	.05989
Methane	2	.00550	.00560	.00555	.00007
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	136.34	137.98	137.16	1.1597
MPG	2	16.904	17.020	16.962	.08231
HC	2	.19410	.20530	.19970	.00792
CO	2	6.3260	6.5160	6.4210	.13435
CO2	2	230.70	232.75	231.72	1.4496
NOx	2	2.2578	2.3029	2.2803	.03189
Non-Methane HC	2	.18910	.19940	.19425	.00728
Methane	2	.00500	.00590	.00545	.00064
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	121.33	127.17	124.25	4.1295
MPG	2	16.538	16.914	16.726	.26587
HC	2	.13080	.16900	.14990	.02701
CO	2	6.0660	6.2850	6.1755	.15486
CO2	2	232.81	238.52	235.66	4.0376
NOx	2	2.2044	2.2086	2.2065	.00297
Non-Methane HC	2	.12510	.16360	.14435	.02722
Methane	2	.00540	.00570	.00555	.00021
Methanol	0				

Emission Statistics for HWY Driving Cycle
For Catalyst: Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	1.8700	1.9900	1.9300	.08485
MPG	3	17.107	17.398	17.255	.14522
HC	3	.00830	.01090	.00920	.00147
CO	3	.31800	.41200	.37633	.05094
CO2	3	235.58	239.92	237.72	2.1708
NOx	3	.29720	.42240	.34757	.06609
Non-Methane HC	3	.00600	.00890	.00710	.00157
Methane	3	.00200	.00230	.00210	.00017
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	2.4400	2.9300	2.6850	.34648
MPG	2	17.010	17.082	17.046	.05070
HC	2	.00800	.00850	.00825	.00035
CO	2	-.00300	.01000	.00350	.00919
CO2	2	240.70	241.73	241.21	.72832
NOx	2	2.5117	2.5744	2.5430	.04434
Non-Methane HC	2	.00520	.00540	.00530	.00014
Methane	2	.00280	.00310	.00295	.00021
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	2.3800	3.3900	2.9000	.50567
MPG	3	16.871	17.153	17.036	.14653
HC	3	.00790	.01060	.00897	.00144
CO	3	0.	.00400	.00233	.00208
CO2	3	240.48	244.45	241.99	2.1510
NOx	3	2.5116	2.7254	2.6146	.10711
Non-Methane HC	1	.00510	.00510	.00510	
Methane	1	.00330	.00330	.00330	
Methanol	0				

Emission Statistics for HWY Driving Cycle
For Catalyst: Silver (Ag)(150)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	1.9200	3.1500	2.3633	.68311
MPG	3	17.024	17.159	17.101	.06971
HC	3	.02090	.02690	.02393	.00300
CO	3	4.0920	4.3630	4.2553	.14382
CO2	3	232.73	235.15	233.88	1.2140
NOx	3	2.7203	2.7685	2.7431	.02421
Non-Methane HC	3	.01590	.02220	.01920	.00316
Methane	3	.00450	.00500	.00473	.00025
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	1.4500	2.4400	1.8575	.41660
MPG	4	16.997	17.532	17.282	.23273
HC	4	.01630	.02280	.01900	.00312
CO	4	3.2910	3.6750	3.4687	.19305
CO2	4	229.00	237.43	232.63	3.7179
NOx	4	2.5562	2.7236	2.6422	.07063
Non-Methane HC	4	.01180	.01790	.01430	.00294
Methane	4	.00430	.00490	.00470	.00027
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	4.5000	5.3600	4.9467	.43097
MPG	3	17.063	18.889	17.822	.95129
HC	3	.02130	.02490	.02333	.00184
CO	3	5.0320	5.2250	5.1190	.09789
CO2	3	210.37	233.08	223.33	11.692
NOx	3	2.2555	2.6862	2.5110	.22630
Non-Methane HC	3	.01620	.02060	.01870	.00226
Methane	3	.00430	.00510	.00463	.00042
Methanol	0				

Emission Statistics for HWY Driving Cycle
For Catalyst: Acid Dipped Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	142.38	168.32	153.53	13.346
MPG	4	18.668	18.928	18.777	.11873
HC	4	.02050	.03570	.02982	.00677
CO	4	1.7600	3.4560	2.9752	.81567
CO2	4	212.31	216.29	214.53	1.6590
NOx	4	1.8778	2.3266	2.1771	.20468
Non-Methane HC	4	.01550	.03020	.02452	.00647
Methane	4	.00490	.00580	.00530	.00042
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	77.820	127.40	99.840	25.250
MPG	3	17.139	17.261	17.191	.06268
HC	3	.02860	.03980	.03330	.00581
CO	3	2.3220	2.8030	2.5813	.24270
CO2	3	233.94	236.21	235.42	1.2854
NOx	3	2.5093	2.5907	2.5451	.04156
Non-Methane HC	3	.02260	.03390	.02733	.00587
Methane	3	.00590	.00600	.00597	.00006
Methanol	0				

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	19.220	19.582	19.365	.19131
HC	3	.00630	.00820	.00710	.00098
CO	3	.12200	.23600	.16833	.05992
CO2	3	209.68	213.51	211.95	2.0095
NOx	3	.85450	1.0487	.93237	.10266
Non-Methane HC	3	.00510	.00570	.00547	.00032
Methane	3	.00070	.00250	.00163	.00090
Methanol	0				

Emission Statistics for HWY Driving Cycle
For Catalyst: Pd + Base Metal(5)

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	17.516	17.898	17.745	.20195
HC	3	.01130	.01250	.01207	.00067
CO	3	0.	.00900	.00333	.00493
CO2	3	229.66	235.48	231.92	3.1223
NOx	3	2.6096	2.7200	2.6509	.06024
Non-Methane HC	3	.00630	.00830	.00750	.00106
Methane	3	.00410	.00500	.00457	.00045
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	1	17.742	17.742	17.742	
HC	1	.01440	.01440	.01440	
CO	1	.00600	.00600	.00600	
CO2	1	231.97	231.97	231.97	
NOx	1	2.6466	2.6466	2.6466	
Non-Methane HC	1	.00970	.00970	.00970	
Methane	1	.00470	.00470	.00470	
Methanol	0				

Emission Statistics for HWY Driving Cycle
For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	26	69.130	215.12	146.52	38.958
MPG	29	16.639	19.736	18.008	.99567
HC	30	.38310	.49160	.43080	.03020
CO	30	4.6970	7.0030	6.2112	.72997
CO2	29	198.95	236.38	218.24	11.563
NOx	30	2.1862	3.0248	2.6469	.23271
Non-Methane HC	25	.38010	.48570	.42453	.03000
Methane	25	.00050	.00590	.00382	.00156
Methanol	5	.17900	.91800	.69280	.30907

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	5	129.94	179.60	159.67	21.215
MPG	5	17.081	17.528	17.340	.18174
HC	5	.36230	.47060	.40718	.05331
CO	5	5.7830	6.7070	6.2158	.44040
CO2	5	223.05	228.77	226.43	2.3445
NOx	5	2.6645	2.9541	2.8133	.10315
Non-Methane HC	3	.36180	.37980	.36843	.00989
Methane	3	0.	.00050	.00027	.00025
Methanol	3	.88800	.94800	.92733	.03408

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	6	121.86	147.00	137.97	8.4228
MPG	6	17.030	17.525	17.301	.19503
HC	6	.33430	.47930	.39817	.06461
CO	6	5.9490	6.8050	6.3000	.32754
CO2	6	224.12	230.98	226.82	2.4939
NOx	6	2.7454	2.9443	2.8384	.08537
Non-Methane HC	2	.39000	.47150	.43075	.05763
Methane	2	.00270	.00490	.00380	.00156
Methanol	3	.79500	.93700	.87167	.07168

Emission Statistics for HWY Driving Cycle
For Catalyst: 5Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	0.	.70000	.22500	.32016
MPG	4	17.969	18.201	18.084	.10126
HC	4	.00060	.00400	.00165	.00159
CO	4	.08000	.15000	.11000	.03424
CO2	4	225.55	229.10	227.44	1.4719
NOx	4	.04650	.13320	.09182	.04113
Non-Methane HC	3	.00070	.00120	.00090	.00026
Methane	3	-.00040	.00330	.00110	.00195
Methanol	4	.00200	.00700	.00375	.00222

Emission Statistics for Idle Driving Cycle
For Catalyst: 12Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.03000	.04000	.03500	.00707
MPG	2	129.00	137.00	133.00	5.6569
HC	2	.00110	.00450	.00280	.00240
CO	2	0.	0.	0.	
CO2	2	30.121	31.840	30.980	1.2155
NOx	2	.00340	.00340	.00340	
Non-Methane HC	2	.00010	.00290	.00150	.00198
Methane	2	.00100	.00160	.00130	.00042
Methanol	2	.00430	.00780	.00605	.00247

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.28000	.37000	.32500	.06364
MPG	3	125.00	134.00	130.67	4.9329
HC	3	.00220	.02660	.01073	.01375
CO	3	.00200	.17100	.05933	.09672
CO2	3	30.577	32.965	31.443	1.3223
NOx	3	.01280	.02480	.01740	.00647
Non-Methane HC	3	.00150	.02540	.00990	.01344
Methane	3	.00060	.00120	.00083	.00032
Methanol	3	.00140	.01490	.01000	.00747

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	.75000	1.3300	.97333	.31214
MPG	3	114.00	130.00	122.00	8.0000
HC	3	.00210	.00210	.00210	
CO	3	0.	0.	0.	
CO2	3	31.612	36.097	33.803	2.2443
NOx	3	.00810	.01510	.01103	.00364
Non-Methane HC	3	.00110	.00120	.00117	.00006
Methane	3	.00090	.00100	.00093	.00006
Methanol	2	.00210	.00220	.00215	.00007

Emission Statistics for Idle Driving Cycle
For Catalyst: 12Pt:Rh(40) - Racetrack

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.45000	1.3400	.89500	.62933
MPG	2	134.00	146.00	140.00	8.4853
HC	2	.00200	.00300	.00250	.00071
CO	2	0.	0.	0.	
CO2	2	28.273	30.639	29.456	1.6730
NOx	2	.00530	.01690	.01110	.00820
Non-Methane HC	2	.00130	.00240	.00185	.00078
Methane	2	.00060	.00070	.00065	.00007
Methanol	1	.01260	.01260	.01260	

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	1.5200	1.5200	1.5200	
MPG	1	119.00	119.00	119.00	
HC	1	.00370	.00370	.00370	
CO	1	.00500	.00500	.00500	
CO2	1	34.498	34.498	34.498	
NOx	1	.02310	.02310	.02310	
Non-Methane HC	1	.00300	.00300	.00300	
Methane	1	.00070	.00070	.00070	
Methanol	1	.00690	.00690	.00690	

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	132.00	134.00	133.00	1.4142
HC	2	.00270	.00470	.00370	.00141
CO	2	0.	.00200	.00100	.00141
CO2	2	30.789	31.289	31.039	.35355
NOx	2	.00520	.00930	.00725	.00290
Non-Methane HC	1	.00410	.00410	.00410	
Methane	1	.00060	.00060	.00060	
Methanol	0				

Emission Statistics for Idle Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	10.380	10.380	10.380	
MPG	3	112.00	124.00	117.00	6.2450
HC	3	.00580	.07150	.03217	.03472
CO	3	0.	.27100	.10900	.14306
CO2	3	33.116	36.091	34.996	1.6355
NOx	3	.02370	.03290	.02707	.00507
Non-Methane HC	3	.00510	.07080	.03140	.03475
Methane	3	.00070	.00090	.00077	.00012
Methanol	1	.03420	.03420	.03420	

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	49.640	56.260	52.950	4.6810
MPG	2	111.00	121.00	116.00	7.0711
HC	2	.03590	.07090	.05340	.02475
CO	2	.00200	.00500	.00350	.00212
CO2	2	33.710	36.884	35.297	2.2444
NOx	2	.01410	.01880	.01645	.00332
Non-Methane HC	0				
Methane	0				
Methanol	0				

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	.45000	14.160	8.7333	7.2878
MPG	3	119.00	121.00	119.67	1.1547
HC	3	.00240	.13710	.05113	.07467
CO	3	.00200	.49300	.16567	.28348
CO2	3	33.535	34.632	34.020	.55931
NOx	3	.00410	.02400	.01217	.01047
Non-Methane HC	2	.00170	.01300	.00735	.00799
Methane	2	.00070	.00090	.00080	.00014
Methanol	1	.43150	.43150	.43150	

Emission Statistics for Idle Driving Cycle
For Catalyst: Pd(40)

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	4.0400	11.160	7.6000	5.0346
MPG	2	123.00	124.00	123.50	.70711
HC	2	.00440	.00810	.00625	.00262
CO	2	0.	.00300	.00150	.00212
CO2	2	33.179	33.394	33.286	.15203
NOx	2	.01080	.01230	.01155	.00106
Non-Methane HC	2	.00380	.00660	.00520	.00198
Methane	2	.00060	.00150	.00105	.00064
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	26.820	29.110	27.965	1.6193
MPG	2	116.00	121.00	118.50	3.5355
HC	2	.00980	.01640	.01310	.00467
CO	2	.00200	.00800	.00500	.00424
CO2	2	34.051	35.412	34.731	.96237
NOx	2	.00820	.02240	.01530	.01004
Non-Methane HC	2	.00860	.01490	.01175	.00445
Methane	2	.00120	.00150	.00135	.00021
Methanol	0				

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	13.240	13.380	13.310	.09900
MPG	1	136.00	136.00	136.00	
HC	2	.08050	.08970	.08510	.00651
CO	2	.36400	.41600	.39000	.03677
CO2	1	29.361	29.361	29.361	
NOx	2	.02310	.02440	.02375	.00092
Non-Methane HC	2	.07950	.08890	.08420	.00665
Methane	2	.00080	.00100	.00090	.00014
Methanol	0				

Emission Statistics for Idle Driving Cycle
For Catalyst: Pd + Base Metal(35)

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	1	128.00	128.00	128.00	
HC	2	.09990	.12220	.11105	.01577
CO	2	.40500	.45100	.42800	.03253
CO2	1	31.261	31.261	31.261	
NOx	2	.02440	.02990	.02715	.00389
Non-Methane HC	2	.09820	.12180	.11000	.01669
Methane	2	.00040	.00170	.00105	.00092
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	118.00	123.00	120.50	3.5355
HC	2	.13370	.13650	.13510	.00198
CO	2	.60000	.64200	.62100	.02970
CO2	2	32.014	33.424	32.719	.99702
NOx	2	.04310	.04560	.04435	.00177
Non-Methane HC	2	.13180	.13530	.13355	.00247
Methane	2	.00120	.00190	.00155	.00049
Methanol	0				

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	124.00	127.00	125.50	2.1213
HC	2	.14360	.14730	.14545	.00262
CO	2	.53500	.62500	.58000	.06364
CO2	2	31.234	31.716	31.475	.34083
NOx	2	.02620	.03290	.02955	.00474
Non-Methane HC	2	.14210	.14580	.14395	.00262
Methane	2	.00150	.00150	.00150	
Methanol	0				

Emission Statistics for Idle Driving Cycle
For Catalyst: Copper (Cu) Mesh

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	118.00	121.00	119.50	2.1213
HC	2	.14010	.16110	.15060	.01485
CO	2	.59000	.82000	.70500	.16263
CO2	2	32.273	33.317	32.795	.73822
NOx	2	.02640	.02790	.02715	.00106
Non-Methane HC	2	.13910	.16040	.14975	.01506
Methane	2	.00070	.00100	.00085	.00021
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	112.00	118.00	115.00	4.2426
HC	2	.15660	.17050	.16355	.00983
CO	2	.57100	.67400	.62250	.07283
CO2	2	33.575	35.190	34.382	1.1420
NOx	2	.02960	.03020	.02990	.00042
Non-Methane HC	2	.15470	.16980	.16225	.01068
Methane	2	.00070	.00190	.00130	.00085
Methanol	0				

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	109.00	127.00	120.00	9.6437
HC	3	.00150	.07660	.03510	.03817
CO	3	.06700	.22400	.13800	.07957
CO2	3	32.199	37.319	34.069	2.8250
NOx	3	.00080	.01270	.00670	.00595
Non-Methane HC	3	.00050	.07500	.03383	.03786
Methane	3	.00100	.00160	.00127	.00031
Methanol	0				

Emission Statistics for Idle Driving Cycle
For Catalyst: Pd(20)

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	124.00	126.00	125.00	1.4142
HC	2	.00750	.01160	.00955	.00290
CO	2	.00200	.00800	.00500	.00424
CO2	2	32.526	33.168	32.847	.45396
NOx	2	.01550	.02290	.01920	.00523
Non-Methane HC	2	.00630	.01090	.00860	.00325
Methane	2	.00070	.00120	.00095	.00035
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	119.00	123.00	121.67	2.3094
HC	3	.02070	.02870	.02423	.00408
CO	3	0.	.00500	.00233	.00252
CO2	3	33.275	34.482	33.694	.68262
NOx	3	.02350	.02710	.02497	.00189
Non-Methane HC	1	.02190	.02190	.02190	
Methane	1	.00140	.00140	.00140	
Methanol	0				

Emission Statistics for Idle Driving Cycle
For Catalyst: Silver (Ag)(150)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	123.00	132.00	127.50	6.3640
HC	2	.04150	.06630	.05390	.01754
CO	2	.45500	.48800	.47150	.02334
CO2	2	30.292	32.637	31.464	1.6582
NOx	2	.01870	.01980	.01925	.00078
Non-Methane HC	2	.04020	.06550	.05285	.01789
Methane	2	.00080	.00130	.00105	.00035
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	104.00	122.00	113.00	12.728
HC	2	.05380	.12590	.08985	.05098
CO	2	.72200	.84000	.78100	.08344
CO2	2	32.433	37.774	35.103	3.7767
NOx	2	.01640	.02410	.02025	.00544
Non-Methane HC	2	.05230	.12410	.08820	.05077
Methane	2	.00150	.00180	.00165	.00021
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	111.00	116.00	113.50	3.5355
HC	2	.10200	.11760	.10980	.01103
CO	2	.82200	.96500	.89350	.10112
CO2	2	33.803	35.105	34.454	.92065
NOx	2	.02450	.02560	.02505	.00078
Non-Methane HC	2	.10050	.11640	.10845	.01124
Methane	2	.00120	.00150	.00135	.00021
Methanol	0				

Emission Statistics for Idle Driving Cycle
For Catalyst: Acid Dipped Copper (Cu) Mesh

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	127.00	132.00	129.00	2.6458
HC	3	.02390	.09860	.05013	.04202
CO	3	.28000	.45800	.35300	.09322
CO2	3	30.719	31.653	31.216	.46982
NOx	3	.01610	.01990	.01743	.00214
Non-Methane HC	3	.02320	.09760	.04920	.04195
Methane	3	.00070	.00110	.00093	.00021
Methanol	0				

Emission Statistics for Idle Driving Cycle
For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	8	6.9800	24.120	15.922	6.0147
MPG	12	109.00	146.00	130.50	10.414
HC	13	.08150	.15910	.09911	.02066
CO	13	.60200	1.0470	.79000	.15440
CO2	12	26.964	36.002	30.231	2.6334
NOx	13	.01150	.04560	.02280	.00921
Non-Methane HC	12	.08180	.11220	.09322	.01039
Methane	12	-.00030	.00150	.00088	.00063
Methanol	4	.18350	.24670	.21137	.02837

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	15.140	23.550	18.200	4.6492
MPG	3	128.00	143.00	137.67	8.3865
HC	3	.07340	.08730	.07890	.00739
CO	3	.57500	.74900	.63733	.09692
CO2	3	27.610	30.513	28.647	1.6193
NOx	3	.01120	.01570	.01270	.00260
Non-Methane HC	1	.08710	.08710	.08710	
Methane	1	.00020	.00020	.00020	
Methanol	3	.19090	.27010	.22723	.04000

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	19.050	20.160	19.605	.78489
MPG	2	120.00	121.00	120.50	.70711
HC	2	.09810	.09990	.09900	.00127
CO	2	.73500	.77000	.75250	.02475
CO2	2	32.639	32.880	32.759	.17041
NOx	2	.01390	.01500	.01445	.00078
Non-Methane HC	0				
Methane	0				
Methanol	2	.29560	.30640	.30100	.00764

Emission Statistics for Idle Driving Cycle
For Catalyst: 5Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	0.	.13000	.08500	.05802
MPG	4	114.00	124.00	119.75	4.3493
HC	4	.00150	.00530	.00270	.00175
CO	4	.00200	.10800	.02925	.05252
CO2	4	33.125	36.268	34.495	1.3555
NOx	4	0.	.00170	.00062	.00081
Non-Methane HC	3	.00080	.00410	.00207	.00178
Methane	3	.00070	.00120	.00087	.00029
Methanol	4	.00070	.00210	.00150	.00059

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: 12Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.20000	1.9000	1.0500	1.2021
MPG	2	10.000	10.100	10.050	.07071
HC	2	.01200	.02800	.02000	.01131
CO	2	0.	0.	0.	
CO2	2	407.33	412.09	409.71	3.3644
NOx	2	.01000	.04500	.02750	.02475
Non-Methane HC	2	.00200	.02600	.01400	.01697
Methane	2	.00200	.01000	.00600	.00566
Methanol	2	.00800	.06000	.03400	.03677

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	1.3000	11.700	5.9000	5.3028
MPG	3	10.100	10.400	10.267	.15275
HC	3	.02200	.03800	.02800	.00872
CO	3	.01600	.03400	.02767	.01012
CO2	3	382.46	408.00	395.05	12.772
NOx	3	.28400	.30100	.29000	.00954
Non-Methane HC	3	.00900	.02500	.01567	.00833
Methane	3	.01100	.01300	.01233	.00115
Methanol	3	.00600	.00900	.00733	.00153

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	1.8000	5.8000	3.7667	2.0008
MPG	3	9.6000	10.100	9.9333	.28868
HC	3	.01900	.02500	.02300	.00346
CO	3	0.	.01600	.00533	.00924
CO2	3	406.68	430.27	414.64	13.542
NOx	3	.29500	.33100	.30933	.01909
Non-Methane HC	3	.00700	.01200	.01033	.00289
Methane	3	.01200	.01300	.01267	.00058
Methanol	2	.00700	.01300	.01000	.00424

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: 12Pt:Rh(40) - Racetrack

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.20000	2.0000	1.1000	1.2728
MPG	2	10.200	10.500	10.350	.21213
HC	2	.02000	.02100	.02050	.00071
CO	2	0.	0.	0.	
CO2	2	391.84	402.97	397.40	7.8673
NOx	2	.19600	.26700	.23150	.05020
Non-Methane HC	2	.01000	.01100	.01050	.00071
Methane	2	.01000	.01000	.01000	
Methanol	1	.16100	.16100	.16100	

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	1.8000	1.8000	1.8000	
MPG	1	10.000	10.000	10.000	
HC	1	.02300	.02300	.02300	
CO	1	.01800	.01800	.01800	
CO2	1	413.03	413.03	413.03	
NOx	1	.30400	.30400	.30400	
Non-Methane HC	1	.01400	.01400	.01400	
Methane	1	.00900	.00900	.00900	
Methanol	1	.02200	.02200	.02200	

Emission Statistics for 10 MPH Steady State Driving Cycle For Catalyst: 3Pt:2Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	9.8000	10.200	10.000	.28284
HC	2	.02200	.04000	.03100	.01273
CO	2	.15400	.23500	.19450	.05728
CO2	2	404.82	418.21	411.51	9.4646
NOx	2	.04100	.04500	.04300	.00283
Non-Methane HC	1	.03000	.03000	.03000	
Methane	1	.01000	.01000	.01000	
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	64.800	64.800	64.800	
MPG	3	9.6000	9.8000	9.7000	.10000
HC	3	.02500	.09000	.05100	.03440
CO	3	0.	.22200	.07433	.12788
CO2	3	421.59	429.68	425.36	4.0746
NOx	3	.27900	.33900	.30867	.03001
Non-Methane HC	3	.01300	.07500	.03700	.03329
Methane	3	.01200	.01500	.01400	.00173
Methanol	1	.03600	.03600	.03600	

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	293.06	294.49	293.77	1.0112
MPG	1	9.8000	9.8000	9.8000	
HC	1	.10200	.10200	.10200	
CO	1	.00100	.00100	.00100	
CO2	1	421.83	421.83	421.83	
NOx	1	.25800	.25800	.25800	
Non-Methane HC	0				
Methane	0				
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: Pd(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	2.1300	41.530	26.237	21.127
MPG	3	9.7000	9.8000	9.7667	.05774
HC	3	.03300	.17600	.10400	.07150
CO	3	1.6440	3.5690	2.8907	1.0810
CO2	3	415.50	417.69	416.91	1.2235
NOx	3	.00500	.04100	.02533	.01845
Non-Methane HC	2	.02000	.09000	.05500	.04950
Methane	2	.01300	.01300	.01300	
Methanol	1	.51700	.51700	.51700	

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	28.400	44.000	36.200	11.031
MPG	2	9.7000	10.200	9.9500	.35355
HC	2	.04300	.04300	.04300	
CO	2	.00200	.03600	.01900	.02404
CO2	2	403.61	422.21	412.91	13.153
NOx	2	.24300	.26300	.25300	.01414
Non-Methane HC	2	.02500	.02700	.02600	.00141
Methane	2	.01600	.01800	.01700	.00141
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	81.200	134.50	107.85	37.689
MPG	2	9.6000	9.7000	9.6500	.07071
HC	2	.03600	.06100	.04850	.01768
CO	2	.00300	.02100	.01200	.01273
CO2	2	426.40	428.43	427.42	1.4326
NOx	2	.23700	.26000	.24850	.01626
Non-Methane HC	2	.01800	.04600	.03200	.01980
Methane	2	.01500	.01800	.01650	.00212
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: Pd + Base Metal(35)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	69.300	82.050	75.675	9.0156
MPG	1	10.300	10.300	10.300	
HC	2	.26100	.30300	.28200	.02970
CO	2	4.9160	5.3980	5.1570	.34083
CO2	1	390.25	390.25	390.25	
NOx	2	.28600	.29600	.29100	.00707
Non-Methane HC	2	.24900	.29200	.27050	.03041
Methane	2	.01100	.01200	.01150	.00071
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	1	10.100	10.100	10.100	
HC	2	.28700	.37600	.33150	.06293
CO	2	5.0180	5.2860	5.1520	.18950
CO2	1	398.10	398.10	398.10	
NOx	2	.28600	.32300	.30450	.02616
Non-Methane HC	2	.27100	.36200	.31650	.06435
Methane	2	.01400	.01600	.01500	.00141
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	9.9000	10.100	10.000	.14142
HC	2	.53100	.54900	.54000	.01273
CO	2	8.4050	9.7530	9.0790	.95318
CO2	2	394.56	398.33	396.45	2.6665
NOx	2	.32900	.34100	.33500	.00849
Non-Methane HC	2	.51700	.53400	.52550	.01202
Methane	2	.01400	.01500	.01450	.00071
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	10.100	10.100	10.100	
HC	2	.62800	.67100	.64950	.03041
CO	2	7.6250	7.9890	7.8070	.25739
CO2	2	391.29	393.26	392.28	1.3873
NOx	2	.30500	.30800	.30650	.00212
Non-Methane HC	2	.61500	.65600	.63550	.02899
Methane	2	.01300	.01500	.01400	.00141
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	10.000	10.100	10.050	.07071
HC	2	.54300	.57500	.55900	.02263
CO	2	7.6760	8.6520	8.1640	.69014
CO2	2	393.28	397.25	395.26	2.8079
NOx	2	.29300	.30100	.29700	.00566
Non-Methane HC	2	.53000	.56500	.54750	.02475
Methane	2	.01000	.01300	.01150	.00212
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	9.9000	10.100	10.000	.14142
HC	2	.60800	.67700	.64250	.04879
CO	2	8.0840	8.2080	8.1460	.08768
CO2	2	394.33	401.13	397.73	4.8083
NOx	2	.30700	.32200	.31450	.01061
Non-Methane HC	2	.59300	.66500	.62900	.05091
Methane	2	.01200	.01500	.01350	.00212
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	10.100	10.100	10.100	
HC	3	.03900	.26500	.16800	.11635
CO	3	2.0140	2.4290	2.2187	.20756
CO2	3	402.21	403.17	402.75	.49449
NOx	3	.01000	.04600	.03367	.02050
Non-Methane HC	3	.02300	.24900	.15300	.11677
Methane	3	.01300	.01600	.01500	.00173
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	10.000	10.100	10.050	.07071
HC	2	.07100	.07400	.07250	.00212
CO	2	.02100	.03500	.02800	.00990
CO2	2	407.28	413.02	410.15	4.0588
NOx	2	.27900	.28100	.28000	.00141
Non-Methane HC	2	.05800	.05800	.05800	
Methane	2	.01300	.01600	.01450	.00212
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	9.9000	10.100	10.033	.11547
HC	3	.10600	.11200	.10900	.00300
CO	3	.01800	.06600	.04500	.02456
CO2	3	405.27	414.17	408.45	4.9603
NOx	3	.27100	.27600	.27400	.00265
Non-Methane HC	1	.09630	.09630	.09630	
Methane	1	.01570	.01570	.01570	
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: Silver (Ag)(150)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	9.9000	10.200	10.050	.21213
HC	2	.19700	.29000	.24350	.06576
CO	2	6.4910	6.8390	6.6650	.24607
CO2	2	391.65	403.09	397.37	8.0858
NOx	2	.29200	.29800	.29500	.00424
Non-Methane HC	2	.18380	.28000	.23190	.06802
Methane	2	.01000	.01320	.01160	.00226
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	9.8000	10.100	9.9500	.21213
HC	2	.21600	.54800	.38200	.23476
CO	2	9.2610	9.6010	9.4310	.24042
CO2	2	390.67	401.85	396.26	7.9069
NOx	2	.25100	.36700	.30900	.08202
Non-Methane HC	2	.21600	.53470	.37535	.22535
Methane	2	0.	.01330	.00665	.00940
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	9.8000	10.000	9.9000	.14142
HC	2	.42600	.65300	.53950	.16051
CO	2	9.5160	10.455	9.9855	.66397
CO2	2	395.96	402.71	399.34	4.7730
NOx	2	.28700	.30700	.29700	.01414
Non-Methane HC	2	.40770	.63820	.52295	.16299
Methane	2	.01480	.01830	.01655	.00247
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle
For Catalyst: Acid Dipped Copper (Cu) Mesh

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	10.200	10.600	10.367	.20817
HC	3	.33600	.37400	.35900	.02022
CO	3	5.5200	5.9300	5.7357	.20583
CO2	3	380.01	393.65	387.85	7.0411
NOx	3	.27000	.28600	.27800	.00800
Non-Methane HC	3	.32390	.36370	.34870	.02163
Methane	3	.00850	.01210	.01030	.00180
Methanol	0				

Emission Statistics for 10 MPH Steady State Driving Cycle For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	5	106.85	226.62	144.65	49.194
MPG	12	9.9000	11.500	10.483	.57340
HC	13	.32700	.60200	.43885	.08171
CO	13	6.7790	13.445	9.4363	2.2743
CO2	12	345.15	397.57	377.43	18.140
NOx	13	.17300	.36500	.25385	.06316
Non-Methane HC	12	.31420	.59100	.41996	.07870
Methane	12	.00200	.01770	.01146	.00498
Methanol	1	1.0460	1.0460	1.0460	

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: 12Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.70000	2.2000	1.4500	1.0607
MPG	2	19.600	19.800	19.700	.14142
HC	2	.00500	.01100	.00800	.00424
CO	2	.00800	.02500	.01650	.01202
CO2	2	207.95	209.63	208.79	1.1809
NOx	2	.00800	.05300	.03050	.03182
Non-Methane HC	2	.00400	.00900	.00650	.00354
Methane	2	.00100	.00200	.00150	.00071
Methanol	2	.01600	.02200	.01900	.00424

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	1.0000	2.6000	1.8000	1.1314
MPG	3	19.400	19.800	19.567	.20817
HC	3	.01000	.03900	.02000	.01646
CO	3	0.	.27900	.09333	.16079
CO2	3	208.34	211.83	210.12	1.7458
NOx	3	.41300	.54000	.47767	.06353
Non-Methane HC	3	.00500	.03400	.01500	.01646
Methane	3	.00400	.00600	.00500	.00100
Methanol	3	.00400	.03600	.01500	.01819

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	1.1000	1.6000	1.3500	.35355
MPG	2	19.400	19.400	19.400	
HC	2	.00700	.00800	.00750	.00071
CO	2	0.	0.	0.	
CO2	2	212.18	212.45	212.31	.18738
NOx	2	.44800	.49200	.47000	.03111
Non-Methane HC	2	.00400	.00400	.00400	
Methane	2	.00300	.00400	.00350	.00071
Methanol	1	.00200	.00200	.00200	

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: 12Pt:Rh(40) - Racetrack

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.80000	1.5000	1.1500	.49497
MPG	2	19.600	20.300	19.950	.49497
HC	2	.00800	.01000	.00900	.00141
CO	2	0.	0.	0.	
CO2	2	202.95	210.06	206.51	5.0275
NOx	2	.13300	.41300	.27300	.19799
Non-Methane HC	2	.00500	.00700	.00600	.00141
Methane	2	.00300	.00300	.00300	
Methanol	1	.03900	.03900	.03900	

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	1.5000	1.5000	1.5000	
MPG	1	19.400	19.400	19.400	
HC	1	.01000	.01000	.01000	
CO	1	.00900	.00900	.00900	
CO2	1	212.47	212.47	212.47	
NOx	1	.47100	.47100	.47100	
Non-Methane HC	1	.00700	.00700	.00700	
Methane	1	.00300	.00300	.00300	
Methanol	1	.10100	.10100	.10100	

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.900	19.000	18.950	.07071
HC	2	.01100	.03000	.02050	.01344
CO	2	.45100	.60400	.52750	.10819
CO2	2	216.27	216.90	216.59	.44123
NOx	2	.05100	.05600	.05350	.00354
Non-Methane HC	1	.00700	.00700	.00700	
Methane	1	.00400	.00400	.00400	
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	70.580	70.580	70.580	
MPG	3	18.400	19.200	18.800	.40000
HC	3	.01200	.02900	.01967	.00862
CO	3	-.01500	0.	-.00500	.00866
CO2	3	214.20	223.88	219.06	4.8411
NOx	3	.43000	.53800	.48167	.05415
Non-Methane HC	3	.00800	.02300	.01433	.00777
Methane	3	.00400	.00600	.00533	.00115
Methanol	2	.04700	.05500	.05100	.00566

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	144.94	165.52	155.23	14.552
MPG	2	17.700	19.100	18.400	.98995
HC	2	.09700	.17400	.13550	.05445
CO	2	.00900	.30900	.15900	.21213
CO2	2	215.62	231.70	223.66	11.371
NOx	2	.38000	.42300	.40150	.03041
Non-Methane HC	0				
Methane	0				
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: Pd(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	19.830	20.800	20.315	.68589
MPG	2	17.900	18.100	18.000	.14142
HC	2	.12000	.13400	.12700	.00990
CO	2	1.2760	1.6150	1.4455	.23971
CO2	2	224.51	227.16	225.84	1.8717
NOx	2	.03700	.05200	.04450	.01061
Non-Methane HC	1	.12800	.12800	.12800	
Methane	1	.00600	.00600	.00600	
Methanol	1	.32200	.32200	.32200	

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	91.500	113.60	102.55	15.627
MPG	2	18.500	18.900	18.700	.28284
HC	2	.03900	.05500	.04700	.01131
CO	2	.00900	.01800	.01350	.00636
CO2	2	217.80	221.82	219.81	2.8454
NOx	2	.38900	.45900	.42400	.04950
Non-Methane HC	2	.03400	.05100	.04250	.01202
Methane	2	.00400	.00500	.00450	.00071
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	138.90	138.90	138.90	
MPG	1	18.600	18.600	18.600	
HC	1	.03900	.03900	.03900	
CO	1	.01800	.01800	.01800	
CO2	1	221.60	221.60	221.60	
NOx	1	.37400	.37400	.37400	
Non-Methane HC	1	.03200	.03200	.03200	
Methane	1	.00700	.00700	.00700	
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: Pd + Base Metal(35)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	61.380	61.380	61.380	
MPG	1	19.500	19.500	19.500	
HC	1	.29500	.29500	.29500	
CO	1	3.0950	3.0950	3.0950	
CO2	1	204.86	204.86	204.86	
NOx	1	.45200	.45200	.45200	
Non-Methane HC	1	.29200	.29200	.29200	
Methane	1	.00300	.00300	.00300	
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	1	18.900	18.900	18.900	
HC	1	.42800	.42800	.42800	
CO	1	4.1710	4.1710	4.1710	
CO2	1	210.09	210.09	210.09	
NOx	1	.52800	.52800	.52800	
Non-Methane HC	1	.42200	.42200	.42200	
Methane	1	.00600	.00600	.00600	
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.400	19.700	19.050	.91924
HC	2	.41000	.46100	.43550	.03606
CO	2	4.1170	4.4760	4.2965	.25385
CO2	2	201.22	215.24	208.23	9.9158
NOx	2	.40900	.44500	.42700	.02546
Non-Methane HC	2	.40400	.45500	.42950	.03606
Methane	2	.00600	.00600	.00600	
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.700	19.300	19.000	.42426
HC	2	.54500	.59600	.57050	.03606
CO	2	4.1970	4.2260	4.2115	.02051
CO2	2	205.10	211.75	208.42	4.7016
NOx	2	.50700	.51500	.51100	.00566
Non-Methane HC	2	.53800	.59000	.56400	.03677
Methane	2	.00600	.00700	.00650	.00071
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.800	19.100	18.950	.21213
HC	2	.50000	.54200	.52100	.02970
CO	2	3.6650	4.4530	4.0590	.55720
CO2	2	208.05	209.77	208.91	1.2141
NOx	2	.47800	.55000	.51400	.05091
Non-Methane HC	2	.49400	.53800	.51600	.03111
Methane	2	.00400	.00600	.00500	.00141
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	19.100	19.400	19.250	.21213
HC	2	.44400	.47000	.45700	.01838
CO	2	3.6620	3.8080	3.7350	.10324
CO2	2	204.61	208.63	206.62	2.8412
NOx	2	.42000	.48800	.45400	.04808
Non-Methane HC	2	.43900	.46500	.45200	.01838
Methane	2	.00500	.00500	.00500	
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	18.900	19.400	19.100	.26458
HC	3	.03200	.16800	.08733	.07145
CO	3	.42600	1.2110	.85400	.39729
CO2	3	210.32	216.85	214.00	3.3415
NOx	3	.02300	.12400	.05733	.05774
Non-Methane HC	3	.02600	.16200	.08167	.07128
Methane	3	.00500	.00600	.00567	.00058
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.900	19.400	19.150	.35355
HC	2	.07400	.11800	.09600	.03111
CO	2	.01800	.05800	.03800	.02828
CO2	2	211.52	217.60	214.56	4.3006
NOx	2	.34800	.38400	.36600	.02546
Non-Methane HC	2	.07000	.11200	.09100	.02970
Methane	2	.00400	.00600	.00500	.00141
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	19.000	19.600	19.300	.30000
HC	3	.03600	.12800	.08500	.04629
CO	3	.00100	.00900	.00600	.00436
CO2	3	209.43	216.14	212.76	3.3549
NOx	3	.36800	.44200	.40667	.03711
Non-Methane HC	1	.12300	.12300	.12300	
Methane	1	.00500	.00500	.00500	
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: Silver (Ag)(150)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.400	19.500	18.950	.77782
HC	2	.28500	.32300	.30400	.02687
CO	2	3.4010	3.4240	3.4125	.01626
CO2	2	205.15	217.32	211.24	8.6005
NOx	2	.42600	.42600	.42600	
Non-Methane HC	2	.27970	.31900	.29935	.02779
Methane	2	.00400	.00530	.00465	.00092
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	18.800	19.400	19.100	.42426
HC	2	.19800	.30900	.25350	.07849
CO	2	4.1990	4.3190	4.2590	.08485
CO2	2	205.31	211.22	208.27	4.1776
NOx	2	.31700	.33400	.32550	.01202
Non-Methane HC	1	.19140	.19140	.19140	
Methane	1	.00660	.00660	.00660	
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	19.000	19.600	19.300	.42426
HC	2	.36500	.36600	.36550	.00071
CO	2	4.4730	5.1940	4.8335	.50982
CO2	2	201.98	207.80	204.89	4.1139
NOx	2	.32000	.37000	.34500	.03536
Non-Methane HC	2	.35780	.36080	.35930	.00212
Methane	2	.00520	.00720	.00620	.00141
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle For Catalyst: Acid Dipped Copper (Cu) Mesh

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	19.600	20.200	19.833	.32146
HC	3	.37200	.39400	.38100	.01153
CO	3	3.0120	3.3540	3.1407	.18606
CO2	3	197.82	203.73	201.18	3.0383
NOx	3	.38800	.48400	.42400	.05231
Non-Methane HC	3	.36790	.39000	.37693	.01159
Methane	3	.00400	.00410	.00407	.00006
Methanol	0				

Emission Statistics for 20 MPH Steady State Driving Cycle For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	8	73.740	165.45	126.96	39.281
MPG	16	19.100	22.800	20.175	1.2741
HC	17	.25900	.49400	.38771	.06212
CO	17	3.6200	6.4590	4.5064	.79240
CO2	16	173.80	208.22	196.67	11.782
NOx	17	.19800	.57900	.38094	.13661
Non-Methane HC	16	.25300	.48720	.38227	.06321
Methane	16	.00060	.00700	.00411	.00220
Methanol	4	.85400	1.2190	.98075	.16778

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	84.800	151.20	123.27	34.430
MPG	3	19.400	19.900	19.633	.25166
HC	3	.33400	.34800	.33867	.00808
CO	3	3.8130	4.3120	4.0593	.24956
CO2	3	198.65	204.73	202.30	3.2159
NOx	3	.44200	.49600	.47033	.02710
Non-Methane HC	1	.33200	.33200	.33200	
Methane	1	.00200	.00200	.00200	
Methanol	3	.82600	1.2980	1.0453	.23776

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	104.20	105.90	105.05	1.2021
MPG	2	18.900	19.100	19.000	.14142
HC	2	.32600	.34400	.33500	.01273
CO	2	4.3070	4.4250	4.3660	.08344
CO2	2	207.28	209.48	208.38	1.5578
NOx	2	.42700	.43700	.43200	.00707
Non-Methane HC	0				
Methane	0				
Methanol	2	1.0840	1.2980	1.1910	.15132

Emission Statistics for 20 MPH Steady State Driving Cycle
For Catalyst: 5Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	.20000	.30000	.22500	.05000
MPG	4	18.900	19.800	19.375	.36856
HC	4	.00500	.01000	.00700	.00245
CO	4	.01600	.15000	.04975	.06684
CO2	4	207.98	217.31	212.30	3.8302
NOx	4	-.00200	.00500	.00075	.00299
Non-Methane HC	3	.00100	.00500	.00233	.00231
Methane	3	.00400	.00500	.00433	.00058
Methanol	4	.00100	.00500	.00275	.00171

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: 12Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.30000	.40000	.35000	.07071
MPG	2	21.500	21.600	21.550	.07071
HC	2	.00200	.00300	.00250	.00071
CO	2	.01700	.02800	.02250	.00778
CO2	2	190.88	191.72	191.30	.59256
NOx	2	.00200	.00500	.00350	.00212
Non-Methane HC	2	.00100	.00200	.00150	.00071
Methane	2	.00100	.00100	.00100	
Methanol	2	.00200	.00800	.00500	.00424

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	.90000	3.0000	2.2000	1.1358
MPG	3	21.200	21.600	21.433	.20817
HC	3	.00800	.00900	.00833	.00058
CO	3	0.	.00100	.00033	.00058
CO2	3	190.45	194.45	192.16	2.0606
NOx	3	1.1400	1.2150	1.1883	.04193
Non-Methane HC	3	.00400	.00600	.00500	.00100
Methane	3	.00300	.00400	.00333	.00058
Methanol	3	.00200	.00500	.00367	.00153

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.60000	2.2000	1.4000	1.1314
MPG	2	21.200	21.400	21.300	.14142
HC	2	.00800	.00800	.00800	
CO	2	0.	0.	0.	
CO2	2	192.32	194.05	193.18	1.2219
NOx	2	1.1740	1.2620	1.2180	.06222
Non-Methane HC	2	.00400	.00500	.00450	.00071
Methane	2	.00300	.00400	.00350	.00071
Methanol	1	.00300	.00300	.00300	

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: 12Pt:Rh(40) - Racetrack

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	.50000	6.7000	3.6000	4.3841
MPG	2	21.000	21.700	21.350	.49497
HC	2	.00600	.00700	.00650	.00071
CO	2	0.	.02300	.01150	.01626
CO2	2	189.78	196.26	193.02	4.5771
NOx	2	.39500	.56200	.47850	.11809
Non-Methane HC	2	.00400	.00500	.00450	.00071
Methane	2	.00200	.00200	.00200	
Methanol	1	.02400	.02400	.02400	

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	5.6000	5.6000	5.6000	
MPG	1	20.300	20.300	20.300	
HC	1	.01000	.01000	.01000	
CO	1	.02900	.02900	.02900	
CO2	1	203.14	203.14	203.14	
NOx	1	1.2180	1.2180	1.2180	
Non-Methane HC	1	.00700	.00700	.00700	
Methane	1	.00300	.00300	.00300	
Methanol	1	.05200	.05200	.05200	

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.200	21.000	20.600	.56569
HC	2	.00600	.01300	.00950	.00495
CO	2	.18900	.25000	.21950	.04313
CO2	2	195.77	203.14	199.46	5.2071
NOx	2	.02700	.06100	.04400	.02404
Non-Methane HC	1	.00900	.00900	.00900	
Methane	1	.00400	.00400	.00400	
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	70.740	70.740	70.740	
MPG	3	19.400	20.200	19.867	.41633
HC	3	.01700	.05800	.03600	.02066
CO	3	0.	.03400	.01333	.01815
CO2	3	204.26	211.46	207.28	3.7359
NOx	3	1.1940	1.2770	1.2300	.04258
Non-Methane HC	3	.01400	.05500	.03267	.02074
Methane	3	.00300	.00400	.00333	.00058
Methanol	2	.04200	.16800	.10500	.08910

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	98.950	114.98	106.96	11.335
MPG	2	19.600	20.800	20.200	.84853
HC	2	.02400	.10000	.06200	.05374
CO	2	.00600	.12300	.06450	.08273
CO2	2	198.28	209.36	203.82	7.8369
NOx	2	1.0880	1.2240	1.1560	.09617
Non-Methane HC	0				
Methane	0				
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: Pd(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	3.2800	3.7800	3.5300	.35355
MPG	2	20.200	20.400	20.300	.14142
HC	2	.01300	.01400	.01350	.00071
CO	2	.47500	.62700	.55100	.10748
CO2	2	201.47	202.52	201.99	.74176
NOx	2	.00500	.01000	.00750	.00354
Non-Methane HC	1	.01000	.01000	.01000	
Methane	1	.00300	.00300	.00300	
Methanol	1	.03600	.03600	.03600	

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	14.800	21.600	18.200	4.8083
MPG	2	20.400	20.700	20.550	.21213
HC	2	.00900	.01000	.00950	.00071
CO	2	.00600	.00600	.00600	
CO2	2	199.13	201.95	200.54	1.9926
NOx	2	1.0260	1.0830	1.0545	.04030
Non-Methane HC	2	.00600	.00600	.00600	
Methane	2	.00300	.00400	.00350	.00071
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	22.900	22.900	22.900	
MPG	1	20.700	20.700	20.700	
HC	1	.01100	.01100	.01100	
CO	1	.00700	.00700	.00700	
CO2	1	198.85	198.85	198.85	
NOx	1	1.0730	1.0730	1.0730	
Non-Methane HC	1	.00700	.00700	.00700	
Methane	1	.00400	.00400	.00400	
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: Pd + Base Metal(35)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	1	38.050	38.050	38.050	
MPG	1	21.500	21.500	21.500	
HC	1	.06600	.06600	.06600	
CO	1	2.1990	2.1990	2.1990	
CO2	1	187.40	187.40	187.40	
NOx	1	1.1090	1.1090	1.1090	
Non-Methane HC	1	.06300	.06300	.06300	
Methane	1	.00300	.00300	.00300	
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	1	21.200	21.200	21.200	
HC	1	.13700	.13700	.13700	
CO	1	3.9770	3.9770	3.9770	
CO2	1	187.66	187.66	187.66	
NOx	1	1.0670	1.0670	1.0670	
Non-Methane HC	1	.13200	.13200	.13200	
Methane	1	.00500	.00500	.00500	
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.900	21.500	21.200	.42426
HC	2	.25200	.25800	.25500	.00424
CO	2	4.4700	4.5760	4.5230	.07495
CO2	2	184.03	188.83	186.43	3.3991
NOx	2	1.0560	1.0940	1.0750	.02687
Non-Methane HC	2	.24700	.25400	.25050	.00495
Methane	2	.00400	.00500	.00450	.00071
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: Copper (Cu) Mesh

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.900	21.200	21.050	.21213
HC	2	.39400	.40300	.39850	.00636
CO	2	4.8710	5.2200	5.0455	.24678
CO2	2	185.18	187.37	186.27	1.5521
NOx	2	1.1130	1.1190	1.1160	.00424
Non-Methane HC	2	.39000	.39700	.39350	.00495
Methane	2	.00400	.00600	.00500	.00141
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.800	21.000	20.900	.14142
HC	2	.40800	.41200	.41000	.00283
CO	2	4.3420	5.0560	4.6990	.50487
CO2	2	188.01	189.02	188.51	.70923
NOx	2	1.1070	1.1190	1.1130	.00849
Non-Methane HC	2	.40500	.40800	.40650	.00212
Methane	2	.00300	.00400	.00350	.00071
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.500	21.300	20.900	.56569
HC	2	.28800	.37500	.33150	.06152
CO	2	3.4560	4.3700	3.9130	.64630
CO2	2	186.54	192.54	189.54	4.2455
NOx	2	.81600	1.1130	.96450	.21001
Non-Methane HC	2	.28500	.36800	.32650	.05869
Methane	2	.00300	.00700	.00500	.00283
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: Pd(20)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	20.700	20.900	20.800	.10000
HC	3	.00900	.01800	.01300	.00458
CO	3	.86200	1.3320	1.1260	.24031
CO2	3	195.36	197.41	196.07	1.1654
NOx	3	.01000	.03000	.01833	.01041
Non-Methane HC	3	.00400	.01300	.00800	.00458
Methane	3	.00500	.00500	.00500	
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	21.000	21.400	21.200	.28284
HC	2	.00800	.00900	.00850	.00071
CO	2	-.00400	.00700	.00150	.00778
CO2	2	192.80	195.93	194.37	2.2140
NOx	2	1.0120	1.0180	1.0150	.00424
Non-Methane HC	2	.00400	.00500	.00450	.00071
Methane	2	.00400	.00400	.00400	
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	21.000	21.400	21.167	.20817
HC	3	.00900	.00900	.00900	
CO	3	-.00400	.01100	.00433	.00764
CO2	3	192.34	196.37	194.64	2.0760
NOx	3	1.0180	1.1110	1.0677	.04682
Non-Methane HC	1	.00500	.00500	.00500	
Methane	1	.00400	.00400	.00400	
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: Silver (Ag)(150)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.900	21.900	21.400	.70711
HC	2	.22100	.23300	.22700	.00849
CO	2	4.0860	4.0900	4.0880	.00283
CO2	2	180.87	189.95	185.41	6.4255
NOx	2	.97100	1.1080	1.0395	.09687
Non-Methane HC	2	.21700	.22870	.22285	.00827
Methane	2	.00400	.00430	.00415	.00021
Methanol	0				

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	21.900	22.000	21.950	.07071
HC	2	.12100	.13400	.12750	.00919
CO	2	4.3830	4.8980	4.6405	.36416
CO2	2	178.95	181.07	180.01	1.5040
NOx	2	.90800	.96700	.93750	.04172
Non-Methane HC	1	.12950	.12950	.12950	
Methane	1	.00450	.00450	.00450	
Methanol	0				

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	2	20.700	21.400	21.050	.49497
HC	2	.22300	.28100	.25200	.04101
CO	2	4.7450	5.2130	4.9790	.33093
CO2	2	183.65	190.04	186.84	4.5198
NOx	2	1.0330	1.0650	1.0490	.02263
Non-Methane HC	2	.21810	.27680	.24745	.04151
Methane	2	.00420	.00490	.00455	.00049
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: Acid Dipped Copper (Cu) Mesh

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0				
MPG	3	21.200	21.700	21.400	.26458
HC	3	.31900	.33400	.32800	.00794
CO	3	3.2770	3.5200	3.4157	.12509
CO2	3	183.44	187.40	185.82	2.1021
NOx	3	1.0500	1.1320	1.0983	.04292
Non-Methane HC	2	.32700	.33060	.32880	.00255
Methane	2	.00340	.00400	.00370	.00042
Methanol	0				

Emission Statistics for 30 MPH Steady State Driving Cycle For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	8	72.280	169.30	126.84	34.830
MPG	15	19.800	24.600	22.093	1.5346
HC	16	.30700	.42500	.36125	.03114
CO	16	3.4830	6.0040	4.5374	.77213
CO2	15	160.55	198.55	179.12	11.984
NOx	16	.72300	1.3060	1.0403	.21193
Non-Methane HC	14	.30320	.42370	.35302	.02886
Methane	14	.00060	.00480	.00255	.00149
Methanol	4	.77300	.89700	.83275	.06143

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	104.00	142.10	129.13	21.770
MPG	3	20.600	21.800	21.300	.62450
HC	3	.31400	.33600	.32567	.01106
CO	3	4.1220	4.2960	4.2007	.08819
CO2	3	181.36	192.44	185.97	5.7752
NOx	3	1.1470	1.2420	1.1963	.04761
Non-Methane HC	1	.32600	.32600	.32600	
Methane	1	.00100	.00100	.00100	
Methanol	3	.84800	.92400	.88967	.03853

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	107.10	130.60	115.30	13.262
MPG	3	21.000	21.200	21.133	.11547
HC	3	.31900	.32300	.32100	.00200
CO	3	4.2010	4.5190	4.3890	.16675
CO2	3	185.85	188.00	186.75	1.1151
NOx	3	1.1580	1.2110	1.1810	.02718
Non-Methane HC	0				
Methane	0				
Methanol	3	.89800	.93000	.91267	.01617

Emission Statistics for 30 MPH Steady State Driving Cycle
For Catalyst: 5Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	.40000	2.8000	1.7500	1.0755
MPG	4	20.900	21.700	21.350	.41231
HC	4	.00400	.00600	.00525	.00096
CO	4	.05700	.06900	.06150	.00545
CO2	4	189.23	197.01	192.63	3.8078
NOx	4	0.	.00700	.00225	.00330
Non-Methane HC	4	.00200	.00500	.00325	.00150
Methane	4	-.00100	.00400	.00200	.00216
Methanol	4	.00100	.00900	.00550	.00412

Emission Statistics for 40 MPH Steady State Driving Cycle For No Catalyst

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	166.30	170.50	168.40	2.9698
MPG	2	19.500	21.600	20.550	1.4849
HC	2	.30900	.32900	.31900	.01414
CO	2	3.8130	4.0760	3.9445	.18597
CO2	2	183.91	203.19	193.55	13.636
NOx	2	1.5830	1.6980	1.6405	.08132
Non-Methane HC	2	.30800	.32800	.31800	.01414
Methane	2	.00100	.00100	.00100	
Methanol	2	.72200	.92600	.82400	.14425

Exhaust Oxygen Level is 3%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	2	119.90	150.90	135.40	21.920
MPG	3	19.800	20.600	20.167	.40415
HC	3	.28900	.29900	.29267	.00551
CO	3	3.8650	4.2450	4.0640	.19064
CO2	3	192.37	201.36	197.23	4.5432
NOx	3	1.6010	1.6930	1.6443	.04623
Non-Methane HC	1	.28900	.28900	.28900	
Methane	1	.00100	.00100	.00100	
Methanol	3	.77400	.94700	.84967	.08851

Exhaust Oxygen Level is 5%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	113.50	119.60	116.83	3.0892
MPG	3	19.400	20.200	19.867	.41633
HC	3	.28300	.30700	.29367	.01222
CO	3	3.8950	4.0740	3.9793	.08995
CO2	3	196.24	205.59	200.26	4.8093
NOx	3	1.6270	1.7610	1.6943	.06700
Non-Methane HC	0				
Methane	0				
Methanol	3	.74300	.89100	.80767	.07574

Emission Statistics for 40 MPH Steady State Driving Cycle
For Catalyst: 5Pt:Rh(40)

Exhaust Oxygen Level is 0%

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	4	0.	.64000	.42000	.28612
MPG	4	20.000	21.500	20.775	.61305
HC	4	.00100	.00300	.00200	.00082
CO	4	0.	.03600	.02000	.01566
CO2	4	191.64	206.16	198.49	5.9470
NOx	4	.01500	.25600	.08950	.11220
Non-Methane HC	4	0.	.00300	.00175	.00126
Methane	4	-.00100	.00200	.00025	.00126
Methanol	4	.00100	.00200	.00150	.00058

APPENDIX 6

Unscheduled Maintenance on the VW Rabbit

Appendix 6

Unscheduled Maintenance on the VW Rabbit

Date	Problem	Repair
Aug. 06, 1982	Fuel pump failure	Replaced with pump from local VW dealer
Aug. 10, 1982	Ran out of fuel	Refueled (no catalyst on the vehicle)
Aug. 18, 1982	None	New methanol-protected fuel pump installed
Oct. 26, 1982	Stalls shortly after cold start	Replaced thermal switch, distributor cap and rotor
Nov. 02, 1982	Fuel guage inoperative	Replaced sending unit (Nov. 8)
Nov. 04, 1982	None	Hooked up digital idle stabilizer, per VW instructions.
Nov. 08, 1982	Starter wouldn't disengage	2 relays interchanged by local dealer, old thermal switch installed
Nov. 10, 1982	None	New thermal switch reinstalled
Nov. 19, 1982	High thermocouple reading in catalyst (over 1600°F)	Inspect catalyst, recorder malfunction
Dec. 02, 1982	Emissions change (NOx)	Fuel pump from dealer re-installed for diagnostic purposes
Dec. 07, 1982	Vacuum line to distributor found disconnected	Reconnected vacuum advance hose
Dec. 08, 1982	None	Methanol-protected fuel pump reinstalled
Feb. 07, 1983	NOx change	New O_2 sensor
Apr. 13, 1983	Failed to start on 3 attempts.	New battery installed
May 18, 1983	Stalls and rough idle during cold start	Readjusted idle CO to specifications
May 23, 1983	Emissions change (HC)	Installed new set of spark plugs.

Unscheduled Maintenance on the VW Rabbit - (cont'd)

Date	Problem	Repair
May 31, 1983	None	Change fuel filter
June 9, 1983	Stalling at every idle.	Removed, disassembled, cleaned, reassembled, and then reinstalled fuel distributor.
July 12, 1983	Difficulty in starting (265 seconds of crank time) and vehicle stumbled & had poor response.	Fuel injection parts (including fuel pump) removed and shipped to Volkswagen of Germany for repair or replacement.
Sept. 20, 1983	None	Installed the fuel injection system as returned from Germany.
Oct. 6, 1983	Stalled & would not restart.	Replaced fuel pressure regulator.
Oct. 26, 1983	None	Exhaust system (from manifold to catalyst) insulated.
Oct. 12, 1983	Stalled & required 4 attempts to restart.	Installed new O_2 sensor.
April 12, 1984	Injector #3 had only 1/2 the flow of the other 3 injectors.	Replaced screen in the outlet of the fuel distributor to injector #3.

APPENDIX 7

Steady State Data at
0, 10, 20, and 30 Miles
per Hour

Summary of the Idle Test Results
with Operation as 3-Way Catalysts

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/min)	Fuel Min/gal	Number of Tests
		(g/min)							
None	0	.10	.09	.21	.79	.02	15.9	130	Up to 13
5Pt:Rh(40)	0	.00	.00	.00	.03	.00	.1	120	4
12Pt:Rh(40)	0	.00	.00	.01	.00	.00	.0	133	2
12Pt:Rh(40)*	0	.00	.00	.01**	.00	.01	.9	140	2
3Pt:2Pd(20)	0	.00	.00**	N/A	.00	.01	N/A	133	2
Pd(40)	0	.05	.01	.43**	.17	.01	8.7	120	3
Pd + BM(35)	0	.09	.08	N/A	.39	.02	13.3	136**	2
Cu	0	.15	.14	N/A	.58	.03	N/A	126	2
Pd(20)	0	.04	.03**	N/A	.14	.01	N/A	120	3
Ag(150)	0	.05	.05	N/A	.47	.02	N/A	128	2
Cu, Acid Dipped	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test

Summary of the Idle Test Results with Operation as Oxidizing Catalysts

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/min)	Fuel Min/gal	Number of Tests
		(g/min)							
None	3	.08	.09**	.23	.64	.01	18.2	138	up to 3
5Pt:Rh(40)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	3	.01	.01	.01	.06	.02	.3***	131	3
12Pt:Rh(40)*	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
3Pt:2Pd(20)	3	.03	.03	.03**	.11	.03	10.4**	117	3
Pd(40)	3	.01	.01	N/A	.00	.01	7.6	124	2
Pd + BM(35)	3	.11	.11	N/A	.43	.03	N/A	128**	2
Cu	3	.15	.15	N/A	.70	.03	N/A	120	2
Pd(20)	3	.01	.01	N/A	.01	.02	N/A	125	2
Ag(150)	3	.09	.09	N/A	.78	.02	N/A	113	2
Cu, Acid Dipped	3	.05	.05	N/A	.35	.02	N/A	129	3
Pd + BM(5)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Idle Test Results
with Operation as Oxidizing Catalysts

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/min)	Fuel Min gal	Number of Tests
		(g/min)							
None	5	.10	N/A	.30	.75	.01	19.6	120	2
5Pt:Rh(40)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	5	.00	.00	.00***	.00	.01	1.0	122	3
12Pt:Rh(40)*	5	.00	.00	.01	.01	.02	1.5	119	1
3Pt:2Pd(20)	5	.05	N/A	N/A	.00	.02	53.0	116	2
Pd(40)	5	.01	.01	N/A	.01	.02	28.0	118	2
Pd + BM(35)	5	.14	.13	N/A	.62	.04	N/A	120	2
Cu	5	.16	.16	N/A	.62	.03	N/A	115	2
Pd(20)	5	.02	.02**	N/A	.00	.02	123.0**	121	2
Ag(150)	5	.11	.11	N/A	.89	.03	N/A	114	2
Cu, Acid Dipped	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Test Data at 10 Miles per Hour with 3-Way Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	0	.46	.44	1.05**	10.21	.27	144.6	10.20	10
5Pt:Rh(40)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	0	.02	.01	.03	.00	.03	1.0	10.05	2
12Pt:Rh(40)*	0	.02	.01	.16**	.00	.23	1.1	10.35	2
3Pt:2Pd(20)	0	.03	.03**	N/A	.19	.04	N/A	10.00	2
Pd(40)	0	.10	.06***	.52**	2.89	.03	26.2	9.77	3
Pd + BM(35)	0	.28	.27	N/A	5.16	.29	75.7	10.30**	2
Cu	0	.65	.64	N/A	7.81	.31	N/A	10.10	2
Pd(20)	0	.17	.15	N/A	2.22	.03	N/A	10.10	3
Ag(150)	0	.24	.23	N/A	6.67	.30	N/A	10.05	2
None, Insulated Exhaust	0	.37	.37	N/A	6.87	.19	N/A	11.33	3
Cu, Acid Dipped****	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)****	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests
****with exhaust insulation

Summary of the Test Data at 10 Miles per Hour with Oxidizing Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
5Pt:Rh(40)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	3	.03	.02	.01	.03	.29	5.9	10.27	3
12Pt:Rh(40)*	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
3Pt:2Pd(20)	3	.05	.04	.04**	.07	.31	64.8**	9.70	3
Pd(40)	3	.04	.03	N/A	.02	.25	36.2	9.95	2
Pd + BM(35)	3	.33	.32	N/A	5.15	.30	N/A	10.10**	2
Cu	3	.56	.55	N/A	8.16	.30	N/A	10.05	2
Pd(20)	3	.07	.06	N/A	.03	.28	N/A	10.05	2
Ag(150)	3	.38	.38	N/A	9.43	.31	N/A	9.95	2
Cu, Acid Dipped	3	.36	.35	N/A	5.74	.28	N/A	10.37	3
Pd + BM(5)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Test Data at 10 Miles per Hour
with Oxidizing Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
5Pt:Rh(40)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	5	.02	.01	.01***	.01	.31	3.8	9.93	3
12Pt:Rh(40)*	5	.02	.01	.02	.02	.30	1.8	10.00	1
3Pt:2Pd(20)	5	.10**	N/A	N/A	.00**	.26	293.8	9.80	2
Pd(40)	5	.05	.03	N/A	.01	.25	107.8	9.65	2
Pd + BM(35)	5	.54	.53	N/A	9.08	.34	N/A	10.00	2
Cu	5	.64	.63	N/A	8.15	.31	N/A	10.00	2
Pd(20)	5	.11	.10**	N/A	.04	.27	N/A	10.00	3
Ag(150)	5	.54	.52	N/A	9.99	.30	N/A	9.9	2
Cu, Acid Dipped	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Test Data at 20 Miles per Hour with 3-Way Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	0	.40	.39	.98	4.66	.42	127.0	19.65	up to 14
5Pt:Rh(40)	0	.01	.00***	.00	.05	.00	0.2	19.38	4
12Pt:Rh(40)	0	.01	.01	.02	.02	.03	1.4	19.70	2
12Pt:Rh(40)*	0	.01	.01	.04**	.00	.27	1.2	19.95	2
3Pt:2Pd(20)	0	.02	.01	N/A	.53	.05	N/A	18.95	2
Pd(40)	0	.13	.13**	.32**	1.45	.04	20.3	18.00	2
Pd + BM(35)	0	.30	.29	N/A	3.10	.45	61.4	19.50	1
Cu	0	.57	.56	N/A	4.21	.51	N/A	19.00	2
Pd(20)	0	.09	.08	N/A	.85	.05	N/A	19.10	3
Ag(150)	0	.30	.30	N/A	3.41	.43	N/A	18.95	2
None, Insulated Exhaust	0	.33	.33	N/A	3.77	.22	N/A	22.47	3
Cu, Acid Dipped****	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)****	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 3 tests
****with exhaust insulation

Summary of the Test Data at 20 Miles per Hour with Oxidizing Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	3	.34	.33**	1.05	4.06	.47	123.3	19.63	up to 3
5Pt:Rh(40)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	3	.02	.02	.02	.09	.48	1.8***	19.57	3
12Pt:Rh(40)*	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
3Pt:2Pd(20)	3	.02	.01	.05***	.00	.48	70.6**	18.80	3
Pd(40)	3	.05	.04	N/A	.01	.42	102.6	18.70	2
Pd + BM(35)	3	.43	.42	N/A	4.17	.53	N/A	18.90	1
Cu	3	.52	.52	N/A	4.06	.51	N/A	18.95	2
Pd(20)	3	.10	.09	N/A	.04	.37	N/A	19.15	2
Ag(150)	3	.25	.19**	N/A	4.26	.33	N/A	19.10	2
Cu, Acid Dipped	3	.38	.38	N/A	3.14	.42	N/A	19.83	3
Pd + BM(5)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Test Data at 20 Miles per Hour with Oxidizing Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	5	.34	N/A	1.19	4.37	.43	105.0	19.00	up to 2
5Pt:Rh(40)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	5	.01	.00	.00**	.00	.47	1.4	19.40	2
12Pt:Rh(40)*	5	.01	.01	.10	.01	.47	1.5	19.40	1
3Pt:2Pd(20)	5	.14	N/A	N/A	.16	.40	155.2	18.40	2
Pd(40)	5	.04	.03	N/A	.02	.37	138.9	18.60	1
Pd + BM(35)	5	.44	.43	N/A	4.30	.43	N/A	19.05	2
Cu	5	.46	.45	N/A	3.74	.45	N/A	19.25	2
Pd(20)	5	.09	.12**	N/A	.01	.41	N/A	19.30	3
Ag(150)	5	.37	.36	N/A	4.83	.34	N/A	19.30	2
Cu, Acid Dipped	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test

Summary of the Data at
30 Miles per Hour with 3-Way
Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
		(g/mi)							
None	0	.36	.35	0.83	4.76	1.09	126.8	21.62	Up to 13
5Pt:Rh(40)	0	.01	.00	.01	.06	.00	1.8	21.35	4
12Pt:Rh(40)	0	.00	.00	.00	.02	.00	0.4	21.55	2
12Pt:Rh(40)*	0	.01	.00	.02**	.01	.48	3.6	21.35	2
3Pt:2Pd(20)	0	.01	.01**	N/A	.22	.04	N/A	20.60	2
Pd(40)	0	.01	.01**	.04**	.55	.01	3.5	20.30	2
Pd + BM(35)	0	.07	.06	N/A	2.20	1.11	38.0	21.50	1
Cu	0	.40	.39	N/A	5.05	1.12	N/A	21.05	2
Pd(20)	0	.01	.01	N/A	1.13	.02	N/A	20.80	3
Ag(150)	0	.23	.22	N/A	4.09	1.04	N/A	21.40	2
None, Insulated Exhaust	0	.38	.38	N/A	3.56	.80	N/A	24.00	3
Cu, Acid Dipped	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Data at
30 Miles per Hour with
Oxidizing Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
				(g/mi)					
None	3	.33	.33**	.89	4.20	1.20	129.1	21.30	3
5Pt:Rh(40)	3	N.A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	3	.01	.00	.00	.00	1.19	2.2	21.43	3
12Pt:Rh(40)*	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
3Pt:2Pd(20)	3	.04	.03	.10***	.01	1.23	70.7**	19.88	3
Pd(40)	3	.01	.01***	N/A	.01	1.05	18.2	20.55	2
Pd + BM(35)	3	.14	.13	N/A	3.98	1.07	N/A	21.20	1
Cu	3	.41	.41	N/A	4.69	1.11	N/A	20.90	2
Pd(20)	3	.01	.00	N/A	.00	1.02	N/A	21.20	2
Ag(150)	3	.13	.13**	N/A	4.64	.94	N/A	21.95	2
Cu, Acid Dipped	3	.33	.33***	N/A	3.42	1.10	N/A	21.40	3
Pd + BM(5)	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

Summary of the Data at
30 Miles per Hour with
Oxidizing Catalyst Operation

Catalyst	Oxygen Level (%)	HC	NMHC	Methanol	CO	NOx	Aldehydes (mg/mi)	MPG	Number of Tests
				(g/mi)					
None	5	.32	N/A	.91	4.39	1.18	115.3	21.13	3
5Pt:Rh(40)	5	N.A	N/A	N/A	N/A	N/A	N/A	N/A	0
12Pt:Rh(40)	5	.01	.00	.00**	.00	1.22	1.4	21.30	2
12Pt:Rh(40)*	5	.01	.01	.05	.03	1.22	5.6	20.30	1
3Pt:2Pd(20)	5	.06	N/A	N/A	.06	1.16	107.0	20.20	2
Pd(40)	5	.01	.01	N/A	.01	1.07	22.9	20.70	1
Pd + BM(35)	5	.26	.25	N/A	4.52	1.08	N/A	21.20	2
Cu	5	.33	.33	N/A	3.91	0.96	N/A	20.90	2
Pd(20)	5	.01	.00**	N/A	.01	1.07	N/A	21.17	3
Ag(150)	5	.25	.25	N/A	4.98	1.05	N/A	21.05	2
Cu, Acid Dipped	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Pd + BM(5)	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

N/A means data are not available
*Racetrack, others are round
**based on 1 test
***based on 2 tests

APPENDIX 8

Initial, Low Mileage Data from the Catalyst Durability Evaluation Program

Appendix 8

Test Vehicle Description

1982 Toyota Cressida (Methanol-Fueled)
Vehicle Identification Number: MX62-083780

Engine

Type	4 Stroke Otto Cycle, In-Line 6
Bore	83.0 x 85.0 mm
Displacement	2759 cc (168 CID)
Compression Ratio	10.0:1
Fuel Metering	Two Separate Fuel Injection Systems (The main fuel injection system uses pure methanol; a seperate cold-start fuel injection system uses pure gasoline.)

Drive Train

Transmission Type	4-Speed Automatic with overdrive
Axle Ratio	3.73

Chassis

Type	4-Door Sedan
Tire Size	185/70SR14
Curb Weight	2855 pounds
Test Weight (ETW)	3000 pounds
Actual Dynamometer Horsepower	10.3

Appendix 8

Emissions during the FTP Driving Cycle

Test Number	02 %	CAT#	Test Date	ODOM (km)	Alde- hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth- ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842014	0.0	STOCK	1-19-84	872.0	11.51	11.2786	0.1105	1.0790	362.78	0.0388	0.1076	0.00290
842020	0.0	STOCK	1-20-84	959.3	12.86	11.3806	0.0984	0.9272	360.25	0.0426	0.0967	0.00172
842026	0.0	STOCK	1-24-84	1044.0	13.87	11.6617	0.1219	1.0558	350.74	0.0452	0.1202	0.00170
STRAIGHT PIPE, NO CATALYST:												
842032	0.0	NONE	1-31-84	1130.7	256.16	11.5303	1.2519	22.3398	317.59	1.7638	1.2462	0.00567
842037	0.0	NONE	2-01-84	1220.3	259.28	11.4941	1.5837	24.9270	314.47	1.7253	1.5775	0.00618
842042	0.0	NONE	2-02-84	1305.8	281.30	11.5534	1.4964	25.2086	312.19	1.7124	1.4896	0.00680
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842283	0.0	NONE	2-22-84	1632.6	N/A	11.9362	1.2629	21.5905	306.78	1.6994	1.2612	0.00174
842288	0.0	NONE	2-23-84	1717.0	N/A	11.9511	1.3383	23.7052	303.11	1.6174	1.3355	0.00282
3Pt:2Pd(20):												
842293	0.0	(#1)	2-24-84	1799.2	N/A	12.0699	0.1621	2.2912	336.65	0.2661	0.1581	0.00403
842295	0.0	(#1)	2-25-84	1860.9	N/A	11.5169	0.1531	2.5464	353.03	0.2733	0.1497	0.00340
842297	0.0	(#1)	2-26-84	1923.7	N/A	11.5742	0.1411	2.7212	350.90	0.2575	0.1375	0.00359
Pd(20):												
842299	0.0	(#2)	2-27-84	1985.5	N/A	11.4268	0.1424	1.8250	357.29	0.0852	N/A	N/A
842301	0.0	(#2)	2-28-84	2052.2	N/A	11.9869	0.1694	1.8717	340.35	0.0869	0.1659	0.00354
842303	0.0	(#2)	2-29-84	2113.1	N/A	11.6842	0.1680	3.0838	346.72	0.0991	0.1632	0.00484
842305	0.0	(#2)	3-01-84	2173.9	N/A	11.9883	0.1637	4.4004	336.08	0.1044	0.1594	0.00429
842307	0.0	(#2)	3-02-84	2252.8	N/A	11.9061	0.1583	2.7390	341.42	0.0925	0.1546	0.00370
STRAIGHT PIPE, NO CATALYST:												
842309	0.0	NONE	3-04-84	2330.9	N/A	11.7326	1.9871	27.1212	301.86	1.4996	1.9796	0.00754
842331	0.0	NONE	3-05-84	2414.5	N/A	11.7195	2.1965	28.2208	300.30	1.5772	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842336	0.0	NONE	3-14-84	2629.1	N/A	12.1692	0.9550	9.0980	321.06	2.1493	0.9522	0.00277
842691	0.0	NONE	3-15-84	2711.4	N/A	12.2720	0.9083	9.3026	317.61	2.0895	N/A	N/A
842696	0.0	NONE	3-16-84	2793.7	N/A	12.3265	0.8979	9.6525	315.79	2.0049	0.8973	0.00056
Pd(20):												
842701	0.0	(#2)	3-17-84	2873.8	N/A	12.1713	0.3158	2.0766	333.85	0.3237	0.3130	0.00279
842703	0.0	(#2)	3-18-84	2934.9	N/A	11.9065	0.2895	1.8313	341.65	0.3399	0.2892	0.00034
843000	0.0	(#2)	3-19-84	2996.1	N/A	12.0036	0.2742	1.9883	339.23	0.3001	0.2731	0.00106
843002	6.4	(#2)	3-20-84	3061.9	N/A	12.0030	0.2932	0.6892	341.09	1.3115	0.2917	0.00152
843004	6.4	(#2)	3-21-84	3123.3	N/A	11.9361	0.2593	0.7083	343.42	1.3317	0.2591	0.00024
843006	6.4	(#2)	3-22-84	3184.4	N/A	11.7945	0.2786	0.7568	346.63	1.3220	0.2783	0.00035
STRAIGHT PIPE, NO CATALYST:												
843008	0.0	NONE	3-23-84	3250.2	N/A	12.1920	1.0719	12.2762	314.92	1.9574	1.0692	0.00271
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843013	0.0	NONE	4-10-84	3557.7	N/A	12.2770	1.0521	7.6501	320.04	2.1168	1.0433	0.00879
843018	0.0	NONE	4-11-84	3538.4	N/A	12.1160	0.9979	8.0454	323.95	2.1949	0.9889	0.00897
843156	0.0	NONE	4-12-84	3618.3	N/A	12.3972	0.9282	7.7391	316.54	2.1305	0.9191	0.00909
3Pt:2Pd(20):												
843161	0.0	(#1)	4-13-84	3701.3	N/A	12.2409	0.2540	2.8905	330.95	0.5169	0.2438	0.01025
843163	0.0	(#1)	4-17-84	3762.7	N/A	12.2142	0.2296	2.7702	332.07	0.5206	0.2200	0.00958
843165	0.0	(#1)	4-18-84	3823.6	N/A	12.2893	0.2312	2.7308	329.53	0.4965	0.2231	0.00810
843167	6.2	(#1)	4-19-84	3890.6	N/A	12.1330	0.2590	0.3300	337.52	1.3428	0.2509	0.00811
843171	6.2	(#1)	4-24-84	4012.5	N/A	11.9512	0.2897	0.3729	342.99	1.4140	0.2805	0.00920

Appendix 8

Emissions during the HWY Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842015	0.0	STOCK	1-19-84	892.5	1.44	15.0852	0.0044	1.2184	271.27	0.0043	0.0034	0.00098
842021	0.0	STOCK	1-20-84	992.8	1.97	15.0284	0.0037	1.2398	272.24	0.0031	0.0031	0.00061
842027	0.0	STOCK	1-24-84	1077.9	2.61	15.1913	0.0039	1.2759	269.18	0.0032	0.0016	0.00227
STRAIGHT PIPE, NO CATALYST:												
842033	0.0	NONE	1-31-84	1164.6	170.71	15.1574	0.4770	16.6208	244.50	1.5857	0.4741	0.00288
842038	0.0	NONE	2-01-84	1254.0	153.35	15.1448	0.4821	17.3859	243.44	1.4956	0.4783	0.00383
842282	0.0	NONE	2-02-84	1339.8	N/A	15.2675	0.5008	17.8730	240.33	1.4491	0.4976	0.00324
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842284	0.0	NONE	2-22-84	1650.0	N/A	15.2960	0.4699	16.3412	241.54	1.4347	0.4687	0.00119
842289	0.0	NONE	2-23-84	1750.5	N/A	15.3904	0.4990	17.1448	239.44	1.4196	0.4975	0.00154
3Pt:2Pd(20):												
842294	0.0	(#1)	2-24-84	1833.5	N/A	15.6318	0.0062	0.8689	261.76	0.0757	0.0059	0.00025
842296	0.0	(#1)	2-25-84	1895.1	N/A	15.1883	0.0062	1.3052	268.61	0.0585	N/A	N/A
842298	0.0	(#1)	2-26-84	1956.7	N/A	15.4812	0.0050	1.2346	263.93	0.0508	0.0042	0.00075
Pd(20):												
842300	0.0	(#2)	2-27-84	2023.8	N/A	14.2389	0.0084	1.9874	285.97	0.0103	0.0084	0.00002
842302	0.0	(#2)	2-28-84	2085.5	N/A	15.5006	0.0126	4.8205	258.30	0.0280	0.0097	0.00294
842304	0.0	(#2)	2-29-84	2146.6	N/A	15.5833	0.0135	5.8254	255.12	0.0410	0.0104	0.00311
842306	0.0	(#2)	3-01-84	2207.8	N/A	15.5045	0.0124	4.7811	258.41	0.0465	0.0104	0.00198
842308	0.0	(#2)	3-02-84	2302.3	N/A	15.3437	0.0113	5.2828	260.02	0.0395	0.0090	0.00228
STRAIGHT PIPE, NO CATALYST:												
842310	0.0	NONE	3-04-84	2364.4	N/A	15.3732	0.5847	18.4316	237.21	1.3226	0.5827	0.00197
842332	0.0	NONE	3-05-84	2448.1	N/A	15.1763	0.6472	19.8818	237.50	1.3163	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842337	0.0	NONE	3-14-84	2662.9	N/A	15.6993	0.3871	6.3752	251.03	1.9304	0.3856	0.00153
842692	0.0	NONE	3-15-84	2744.0	N/A	15.8065	0.3812	7.1679	247.65	1.8580	N/A	N/A
842697	0.0	NONE	3-16-84	2826.9	N/A	16.0496	0.3780	7.2062	243.87	1.7970	0.3775	0.00054
Pd(20):												
842702	0.0	(#2)	3-17-84	2907.3	N/A	15.8821	0.0134	0.7602	258.13	0.0602	0.0123	0.00106
842704	0.0	(#2)	3-18-84	2968.3	N/A	15.8800	0.0088	0.7919	257.69	0.0619	0.0087	0.00013
843001	0.0	(#2)	3-19-84	3029.7	N/A	15.8314	0.0089	0.6552	258.81	0.0582	0.0084	0.00048
843003	6.4	(#2)	3-20-84	3095.5	N/A	15.9542	0.0152	0.0080	258.49	1.0547	0.0143	0.00090
843007	6.4	(#2)	3-22-84	3221.5	N/A	15.7102	0.0130	0.0245	262.38	1.0594	0.0129	0.00006
STRAIGHT PIPE, NO CATALYST:												
843009	0.0	NONE	3-23-84	3283.6	N/A	15.9044	0.4247	7.9711	244.99	1.7416	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843014	0.0	NONE	4-10-84	3495.0	N/A	15.5619	0.4494	5.8188	254.48	1.9205	0.4447	0.00471
843019	0.0	NONE	4-11-84	3558.0	N/A	15.5388	0.4340	6.0961	253.96	1.9513	0.4294	0.00464
843157	0.0	NONE	4-12-84	3651.9	N/A	15.7147	0.4071	5.5353	251.70	1.9298	0.4024	0.00469
3Pt:2Pd(20):												
843162	0.0	(#1)	4-13-84	3734.9	N/A	15.8854	0.0106	0.7278	258.41	0.2503	0.0070	0.00361
843164	0.0	(#1)	4-17-84	3795.9	N/A	15.9463	0.0092	0.7391	256.67	0.2774	0.0059	0.00325
843166	0.0	(#1)	4-18-84	3856.7	N/A	16.0087	0.0069	0.7444	256.18	0.2550	0.0035	0.00336
843168	6.2	(#1)	4-19-84	3923.8	N/A	15.8331	0.0122	0.0047	260.14	1.0095	0.0079	0.00432
843170	6.2	(#1)	4-20-84	3984.5	N/A	15.7722	0.0126	0.0000	261.01	1.0517	0.0080	0.00456
843172	6.2	(#1)	4-24-84	4045.7	N/A	15.7121	0.0129	0.0000	261.60	1.1078	0.0082	0.00469

Appendix 8

Emissions during Idle

Test Number	02 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/min)	Mins / Gallon	HC (g/min)	CO (g/min)	CO2 (g/min)	NOx (g/min)	Non-Meth-ane HC (g/min)	METHANE (g/min)
		TOYOTA CATALYST:										
842016	0.0	STOCK	1-19-84	895.2	0.566	94.0	0.0015	0.0135	43.9187	0.0008	0.0008	0.0007
842022	0.0	STOCK	1-20-84	1008.4	0.149	91.0	0.0003	0.0457	44.9817	0.0000	0.0002	0.0001
842028	0.0	STOCK	1-24-84	1094.0	0.00	102.0	0.0007	0.0054	40.3118	0.0000	0.0006	0.0001

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

Appendix 8

Emissions during Steady State Driving at 10 MPH

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842017	0.0	STOCK	1-19-84	898.4	2.54	7.8	0.006	0.897	524.012	0.005	0.0030	0.003
842023	0.0	STOCK	1-20-84	1008.5	1.85	7.9	0.010	2.239	518.317	0.000	0.0092	0.001
842029	0.0	STOCK	1-24-84	1094.0	2.26	13.0	0.005	0.111	317.197	0.005	0.0042	0.001
STRAIGHT PIPE, NO CATALYST:												
842034	0.0	NONE	1-31-84	1181.0	584.58	8.7	3.585	52.889	379.000	0.668	3.5658	0.019
842039	0.0	NONE	2-01-84	1270.6	557.85	8.9	6.569	53.996	358.515	0.634	6.5480	0.020
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842285	0.0	NONE	2-22-84	1670.2	N/A	8.9	4.786	52.632	366.075	0.557	4.7792	0.007
842290	0.0	NONE	2-23-84	1767.0	N/A	8.9	8.565	54.298	347.667	0.650	8.5553	0.010
3Pt:2Pd(20):												
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
842311	0.0	NONE	3-04-84	2383.4	N/A	8.9	9.728	48.269	357.579	0.698	9.7181	0.010
842333	0.0	NONE	3-05-84	2468.8	N/A	8.3	10.325	53.035	379.688	0.837	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842338	0.0	NONE	3-14-84	2680.0	N/A	9.6	0.590	11.036	408.019	0.432	0.5859	0.004
842693	0.0	NONE	3-15-84	2764.5	N/A	9.3	0.591	11.642	420.458	0.573	N/A	N/A
842698	0.0	NONE	3-16-84	2844.0	N/A	13.9	0.560	7.465	282.155	0.258	0.5603	0.000
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843010	0.0	NONE	3-23-84	3300.1	N/A	9.6	1.140	21.971	389.323	0.431	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843015	0.0	NONE	4-10-84	3507.0	N/A	9.7	0.639	10.188	406.570	0.485	0.6229	0.016
843153	0.0	NONE	4-11-84	3568.0	N/A	9.9	0.656	11.869	396.946	0.429	0.6366	0.019
843158	0.0	NONE	4-12-84	3670.9	N/A	9.5	0.625	9.856	417.580	0.577	0.6097	0.016
3Pt:2Pd(20):												

Appendix 8

Emissions during Steady State Driving at 20 MPH

Test Number	02 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842018	0.0	STOCK	1-19-84	935.0	1.42	15.5	0.012	0.394	265.116	0.002	0.0076	0.005
842024	0.0	STOCK	1-20-84	1016.6	7.17	15.3	0.009	0.397	268.274	0.000	0.0061	0.003
842030	0.0	STOCK	1-24-84	1106.2	3.88	16.0	0.012	0.517	255.909	0.000	0.0086	0.004
STRAIGHT PIPE, NO CATALYST:												
842035	0.0	NONE	1-31-84	1194.0	185.26	16.6	0.761	23.438	208.052	0.554	0.7543	0.007
842040	0.0	NONE	2-01-84	1278.0	161.18	17.4	0.771	22.159	199.560	0.586	0.7642	0.006
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842286	0.0	NONE	2-22-84	1686.6	N/A	17.6	0.767	21.896	196.660	0.514	0.7641	0.003
842291	0.0	NONE	2-23-84	1770.0	N/A	17.1	1.248	26.105	195.193	0.501	1.2443	0.003
3Pt:2Pd(20):												
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
842312	0.0	NONE	3-04-84	2387.0	N/A	16.6	3.660	27.249	194.183	0.697	3.6558	0.004

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842689	0.0	NONE	3-14-84	2683.5	N/A	18.4	0.394	5.217	214.361	0.656	0.3917	0.002
842694	0.0	NONE	3-15-84	2768.0	N/A	18.0	0.390	6.021	217.961	0.706	N/A	N/A
842699	0.0	NONE	3-16-84	2847.0	N/A	18.5	0.395	5.763	212.249	0.621	0.3946	0.000
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843011	0.0	NONE	3-23-84	3303.2	N/A	18.7	0.456	8.348	205.866	0.496	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843016	0.0	NONE	4-10-84	3510.0	N/A	18.2	0.462	4.246	217.811	0.692	0.4575	0.005
843154	0.0	NONE	4-11-84	3592.0	N/A	18.5	0.419	4.660	213.953	0.666	0.4129	0.006
843159	0.0	NONE	4-12-84	3674.5	N/A	18.3	0.424	4.632	216.258	0.703	0.4184	0.006
3Pt:2Pd(20):												

Appendix 8

Emissions during Steady State Driving at 30 MPH

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842019	0.0	STOCK	1-19-84	950.0	0.00	23.1	0.005	0.309	177.729	0.003	0.0041	0.001
842025	0.0	STOCK	1-20-84	1023.6	1.88	18.1	0.004	0.272	226.462	0.000	0.0028	0.002
842031	0.0	STOCK	1-24-84	1115.0	1.26	18.6	0.004	0.361	220.231	0.000	0.0018	0.002
STRAIGHT PIPE, NO CATALYST:												
842036	0.0	NONE	1-31-84	1200.0	116.90	18.8	0.522	19.512	186.108	0.799	0.5164	0.006
842041	0.0	NONE	2-01-84	1288.0	119.17	18.0	0.508	19.807	195.673	0.941	0.5036	0.005
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842287	0.0	NONE	2-22-84	1696.4	N/A	18.8	0.522	16.757	191.521	0.933	0.5198	0.002
842292	0.0	NONE	2-23-84	1778.7	N/A	18.4	0.612	19.037	192.127	0.912	0.6088	0.003
3Pt:2Pd(20):												
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
842313	0.0	NONE	3-04-84	2393.0	N/A	18.5	0.741	22.073	185.537	0.773	0.7383	0.003
842335	0.0	NONE	3-05-84	2478.2	N/A	7.5	3.405	63.514	441.030	1.896	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842690	0.0	NONE	3-14-84	2691.3	N/A	18.8	0.388	5.434	209.538	1.269	0.3868	0.001
842695	0.0	NONE	3-15-84	2773.8	N/A	19.8	0.359	6.120	197.433	1.086	0.0000	0.000
842700	0.0	NONE	3-16-84	2853.0	N/A	20.1	0.355	6.296	193.586	0.987	0.3541	0.001
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843012	0.0	NONE	3-23-84	3310.0	N/A	19.7	0.400	6.378	197.907	1.155	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843017	0.0	NONE	4-10-84	3517.0	N/A	19.6	0.459	4.824	200.872	1.250	0.4545	0.004
843155	0.0	NONE	4-11-84	3598.0	N/A	19.7	0.423	5.129	199.336	1.225	0.4180	0.005
843160	0.0	NONE	4-12-84	3680.5	N/A	19.9	0.401	4.932	198.231	1.167	0.3974	0.004
3Pt:2Pd(20):												